Crisis and Individuation:
Mapping and Navigating the Planetary Crisis Convergence

by
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Abstract

We live in an era of converging global crises, from climate change and mass extinction to political-economic turbulence, energy depletion, food crises, and emerging technological risks. But how will these crises combine and feedback on each other? How might they unfold over the coming years and decades? And what can be done to solve or at least navigate these crises? This dissertation argues that answers to these questions have been hindered by limited efforts so far, both in the field of International Relations and beyond, to develop more holistic analyses of these crises. In large part this is due to the dominance of "isolationist" approaches to the study of global crisis and the social sciences more generally: the tendency to analytically isolate specific systems and problems from other systems with which they're connected. While isolationist analyses are vital, I argue that they must be supplemented with multidimensional and synthetic analyses in order to adequately grasp the complexity of the contemporary planetary crisis, or what I call the "planetary crisis convergence", and understand how it may unfold in the coming decades.

Overall, this dissertation presents two core arguments. First, that the contemporary world system is on the cusp of a *catastrophic discontinuity* that will irreversibly transform livelihoods, states, and world order over the next two to four decades. Second, that to see this imminent rupture, understand its causal drivers, and map its possible future trajectories requires a multi-dimensional systems theoretical approach that encompasses political-economic, technological, geological, and ecological processes. To pursue this analysis I develop a theoretical framework drawing from complexity theory, Marxist political economy, and the philosophy of Gilles Deleuze alongside natural scientific studies on climate change, food and energy systems, and technological change. In this way the dissertation synthesizes quantitative analyses of key trends in climate, food, and energy systems with qualitative analysis of political economy, technology, power, and resistance in order to illuminate the possible trajectories of the planetary crisis convergence and inform counter-hegemonic responses. It concludes that these crises will most likely force a transition in the world-system towards one of three global-scale scenarios: a Techno-Authoritarian Planetary Leviathan, an Ecosocialist world-system, or a global collapse. It proposes that a democratic ecosocialist world-system is needed to respond to the planetary crisis convergence in a genuinely sustainable and just manner, which would involve a new political-economy based on well-being, post-growth principles, and democratic planning at multiple scales.

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Daniel Deudney
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Introduction: Crisis and Individuation

There is no shortage of signs that we live in an age defined by “crisis”. Multiple decades of warning about the perils of infinite growth on a finite planet have gone largely unheeded, and the symptoms intensify all around us. Climate change and its effects are already exceeding the worst-case scenario predictions of scientists from a decade ago, leading to an emerging consensus among scientists that we face an imminent “climate emergency” (Ripple et al, 2019). The oceans are acidifying and filling with plastic, along with the stomachs of myriad marine creatures. Rates of biodiversity loss are ascending as if a comet had struck the planet, with over 60% of animal populations being lost since 1970 and insects on pace to be wiped out by the end of the century (World Wildlife Fund, 2018; Sanchez-Bayo & Wyckuhs, 2019). In 2017 over 15,000 scientists from around the world signed off on a “second warning to humanity” (marking the 25th anniversary of the first warning to humanity penned by the Union of Concerned Scientists in 1992), which showed that earth system degradation (with the exception of ozone depletion) has only accelerated since the first warning and is pushing ecosystems to the brink of collapse (Ripple et al, 2017). Meanwhile, the global capitalist engine continues to sputter below its “normal” capacity while accumulating systemic risks threaten to unleash another shock to the system. Years of “quantitative easing” have artificially inflated stock market prices and other assets as an attempt to stimulate growth, yet growth remains slow and precarious, mountains of private and public debt continue to pile up, and many fear the consequences of interest rate “normalization” for an over-indebted global economy (IMF, 2018; Streeck, 2017; Reid et al, 2017; Tooze, 2018).

Closely bound up with such processes, yet dimly recognized by many, is a secular trend towards “net energy decline” as easy to access fossil energy reserves grow increasingly scarce and the global economy increasingly dependent on “unconventional” reserves to power the growth engine (Ahmed, 2017; Hall & Day, 2009; Murphy, 2014). Thus many fear not only the consequences of unrelenting fossil fuel consumption for the earth system but also the prospect of volatile prices and possibly near-term scarcities in the global economy’s “critical master resource” (Homer-Dixon, 2006), with cascading consequences for food production, trade, transportation, economic growth, and geopolitical stability. In the realm of agriculture, yield increases of staple grains like rice and wheat are beginning to plateau, soils are being decimated by decades of chemical inputs and monoculture practices, and water tables are being drawn down far beyond regeneration rates in all the major breadbaskets of the world (Brown, 2012; Janetos et al, 2017). While often unrecognized, all the above processes are already feeding into conflict and state failure across the global south, political instability and reactionary populisms throughout the global north, waves of refugees and internally displaced persons, and a securitized “bunker” mentality among security agencies and analysts in the global north (Ahmed, 2017). Many of the latter continue to foreground “terrorism” as the primary threat to national security in the global north, with cheapening weapons of mass destruction and growing vulnerabilities from networked critical infrastructures stressing state capacities to imagine and prepare for all potential threats (Blum & Wittes, 2015). Yet some intuit an even more dangerous cocktail on the near-term horizon as earth system and political-economic destabilization combine to water the seeds of violent conflict, non-state terrorism, state repression, neo-fascist racism, and revolutionary anger across the globe (Ahmed et al, 2015; Rogers, 2008).

It is thus often said that we live in an age of "converging crises" (George, 2010), a "perfect storm" of challenges (Beddington, 2009), or a "catastrophic convergence" (Parenti, 2011). And there is no shortage of books, articles, research funding, think-tanks, intellectual and political energy from across the political spectrum being devoted to analyzing these crises, understanding their underlying causal mechanisms, and formulating plausible solutions. Excellent analyses exist across the natural and social sciences, from International Relations (IR) to Geography, Sociology, the incipient Earth System Sciences, and others. Most analyses tend to focus a single dimension of the above "crisis architecture" (Homer-Dixon et al, 2015), whether it be climate change or secular stagnation, energy depletion, food crises, violent conflict, non-state terrorism, or state failure. Yet many are also moving towards a more holistic or synthetic form of analysis, especially in regards to the intertwined fates of capitalism and the earth system (Foster, 2013; Moore, 2015), the role of energy depletion in reinforcing the structural crisis of capitalism (Di Muzio, 2015; Ahmed, 2017; Hall & Day, 2009), and the role of earth system crisis and energy depletion in fueling violent conflict (Homer-Dixon, 2001; Barnett, 2007; Klare, 2009; Ahmed, 2017). An inter-disciplinary, even "transdisciplinary", ethos is in the air, with many recognizing the limits of traditional disciplinary boundaries for synthesizing the knowledge needed to understand and navigate these crises (Wainwright, 2010; Costanza et al, 2007; Swilling, 2019). Emerging initiatives, including Future Earth, the Resilience Alliance, FuturICT, IHOPE, new "Integrated Assessment Models" demonstrate that immense (if still inadequate) resources are pouring into these transdisciplinary efforts (Rockström et al, 2009; Helbing, 2011; Future Earth, 2014; Costanza et al, 2012; Van der Leeuw, 2011).

The time is therefore ripe for a “holistic analysis of planetary crisis”[1], which is clearly one of the most urgent ongoing research initiatives in the world today. Yet disciplinary habits die slowly, and synthetic analyses of these crises remain relatively few and far between. Maria Ivanova and colleages, in a recent report for the “Future Earth” global research initiative, articulate the challenge:

> We are only beginning to piece together the ways these different systems interact, and other, unknown or unanticipated, interactions are also likely…Despite this ubiquity of connections, many scientists and policymakers are embedded in institutions that are used to thinking and acting on isolated risks, one at a time (Ivanova et al, 2020: 17).

As a result of these “isolationist” tendencies, I will argue that scholars across the natural and social sciences have yet to develop a theoretical framework that can orient a multidimensional and synthetic analysis of the contemporary crisis convergence, illuminate its possible trajectories, and inform systemic responses that would be in the interests of the human and non-human majority (rather than merely those of global elites). As noted, while many existing approaches provide excellent analyses of specific dimensions of the crisis, or the interactions between two or three dimensions, very few have attempted a more comprehensive multi-dimensional analysis.[2] Furthermore, there has been limited effort to develop a theoretical framework that can weave together a quantitative analysis of key trends in climate, energy, food, and other ecological systems with qualitative analysis of political-economy, power, and resistance: a synthesis between

[1] I place this phrase in scare quotes to emphasize that a truly “holistic” analysis of planetary crisis is an impossibility. One cannot truly see “the whole”, though one can engage in a continuous synthetic mapping of the planetary problematic by illuminating connections between ever-more phenomena (in the Deleuzo-Guattarian fashion of “and, and…”).

[2] The work of Nafeez Ahmed (2010, 2017) is a notable exception, and the approach developed in this dissertation is deeply indebted to his path-breaking analysis.

approaches in the tradition of systems modeling and those in the tradition of political-economic critique and resistance (MacKay, 2017: 12).[3] A large reason for this is of course the continuing salience of disciplinary boundaries in creating a rift between the multiple forms of knowledge that are vital to understanding the present crises, as well as the obvious difficulty of trying to address multiple phenomena simultaneously.

However, I will argue that this is also due to the limited or narrowly circumscribed ontological frameworks on which many existing disciplines, IR in particular, and analyses of planetary crisis are based. In short, we need a theoretical framework that foregrounds the connections between seemingly disparate phenomena, a framework that emphasizes the complex mesh of intersecting political-economic, ecological, and technological processes that is the planetary real and enables us combine quantitative rigor with qualitative attunement to political-economic patterns, relations of power, and forms of resistance. This does not mean eschewing simplification (far from it), since a map that attempts to exhaustively cover the territory it represents would cease to be useful. Furthermore, it does not mean simply rejecting analytic "isolationism" in the natural and social sciences, since isolationist analyses are vital to deepen our understanding of the individual dimensions of our planetary crisis. Rather, it means going beyond these approaches by synthesizing their analyses and insights in a more comprehensive, synthetic, and systematic framework. As the late Immanuel Wallerstein wrote over forty years ago:

[3] This framing was inspired by Kevin MacKay's work on the crisis of civilization (MacKay, 2017). MacKay similarly frames his work as a synthesis between the "systems theory" and "left critical" traditions. While broad, I find this distinction to be useful for highlighting both a lack of critical reflexivity among more scientifically oriented systems modelers and a limited integration of quantitative socio-ecological parameters in much critical theory. Unfortunately, MacKay tends to be unduly dismissive of the Marxist tradition, often reducing it to simplistic caricature, even though it has arguably been at the forefront of such efforts towards theoretical synthesis (as I will argue in chapter 3, especially regarding the sub-field of Ecological Marxism). However, as I will argue in chapter 3, I believe they can and should go further in these efforts, and MacKay's critique is therefore not without warrant.

> Man's ability to participate intelligently in the evolution of his own system is dependent on his ability to perceive the whole. The more difficult we acknowledge the task to be, the more urgent it is that we start sooner rather than later (Wallerstein, 1974a: 10).

Without such an effort, theorists are unable to understand the complexity and severity of the emerging planetary crisis and are unable to envision global systemic responses that are adequate to the challenges we confront.

Overall, this dissertation will present three interrelated core arguments. First, I will argue that the contemporary world system is on the cusp of a *catastrophic discontinuity*, or a *systemic rupture* that will irreversibly transform livelihoods, communities, states, and world order in the coming decades – a qualitative break towards which the international system is inevitably being drawn like a ship caught in a whirlpool. By this I mean to say that the window of opportunity for a continuous or "gradualist" transition to a sustainable world order has closed, and that current trends will culminate in an abrupt and irreversible transition event (or rather a series of events) that will transform states, relations of power, forms of social reproduction, and political-economic institutions across the planet. Second, I argue that to see this imminent rupture, understand its causal drivers, and map the possible trajectories by which it could unfold requires a multi-dimensional and synthetic form of analysis that encompasses political-economic, technological, geological, and ecological systems, processes, and relations. Third, that a theoretical framework drawing from Complexity Theory, Marxist political economy (particularly the sub-fields of World-Systems Theory and Ecological Marxism), and the philosophies of Gilles Deleuze and Gilbert Simondon can provide an overall ontology and "methodology" (if that is the right word) for developing this multi-dimensional analysis of planetary crisis and informing counter-hegemonic responses.

The Contemporary Crisis in Historical Context

I am of course far from the first to proclaim the imminence of catastrophic discontinuities in the world system. Indeed, for many scientists, scholars, and activists this has simply become a truism (Scranton, 2020; Grove, 2019; Ripple et al, 2017, 2019), though it remains intensely resisted by others (e.g. Lomborg, 2012; Kelly, 2012, Pinker, 2018; Schellenberger, 2020). While such arguments have grown increasingly common in the past decade, seen in what John Urry documents as the rise of a "new catastrophism" (Urry, 2016), they also partake in a longer lineage of at least a half century of theory and "prophecy" regarding a cumulative crisis of modernity driven by ecological degradation, the contradiction between planetary problems and inter-state anarchy, and the gradual exhaustion of capitalist growth. Such arguments perhaps date at least back to 20th century Marxists like Rosa Luxembourg,[4] who argued that the capitalist system would eventually reach the limits of geographical and material expansion, which would make it more vulnerable to increasingly intense crises and revolutionary upheaval (Luxemburg, 2000; see also Wallerstein, 1974b). While there was an under-elaborated theory and anticipation of ecological crisis in Marx's work, which has been rediscovered and elaborated by ecological Marxists in recent decades (Foster, 2000), claims regarding the imminence of ecological catastrophe did not become common until at least the warnings of William Vogt in 1948, who was among the first to argue that population growth would soon outstrip the earth's "carrying capacity" (Mann, 2018). Coming during the ascent of

[4] As Saral Sarkar shows, though many assume that Marx believed in the inevitable collapse of capitalism (due to his somewhat propagandist statements in the *Communist Manifesto*), it is difficult if not impossible to locate such an argument within his work. While Volume III of *Capital* elaborates his theory regarding the tendency of the rate of profit to fall, Marx also emphasizes the existence of counter-tendencies that enable capitalists to restore profitability. Thus there is no clear theory or statement of inevitable capitalist breakdown in his work, though later Marxists like Rosa Luxemburg would attempt to develop one (Sarkar, 2012: 24).

what is now called the "great acceleration" – the post world war II take-off in population, economic growth, and resource expansion – Vogt's arguments would later influence Rachel Carson, Paul and Anne Ehrlich, and the Club of Rome. The Ehrlichs argued that population growth and increasing food demands would lead to famine, mass death, and societal upheaval as early as the 1970s and 80s (Ehrlich & Ehrlich, 1968). Taking a more cautious (but still somewhat crude) approach, the Club of Rome met in 1968 to undertake the "Project on the Predicament of Mankind", which utilized advances in computer modeling to analyze the intertwined problems of population growth, industrialization, pollution, and resource depletion as elements of a "world problematique" (Meadows et al, 1972). They concluded that current growth trends would reach their limits within the next one hundred years, which would lead to a "sudden and uncontrollable decline in both population and industrial capacity" if the world system failed to transition to a steady state (ibid: 23-24).

In the field of world politics, arguments about the imminence of ecological catastrophe can be traced back at least to Richard Falk's seminal work in 1971, where he wrote that "We are now living in the first stages of a planetary crisis…We may not have more than a few years to make fundamental adjustments; we certainly do not have more than a few decades" (Falk, 1971: 9, 2). Harold and Margaret Sprout similarly argued that ecological catastrophe represented a creeping threat that would require surmounting the political fragmentation of the international system (Sprout & Sprout, 1971: 485-486). Building on these claims, Dennis Pirages boldly stated in 1978 that

> [t]he next fifty years are likely to be the most revolutionary in the history of relations among nations….In the past, abundant fuels, land, water and other natural resources have been available to sustain high levels of both consumption

> and growth…this extended period of rapid economic growth and expansion is now coming to an end (Pirages, 1978: ix).

Thus while the discipline of IR has not been impervious to such arguments, most anticipations of crisis in the field have focused on the nuclear threat and the contradiction between political fragmentation and the increasingly global nature of survival challenges requiring collective solutions – what could be called the *problematic of interdependence*. As Daniel Deudney shows, turn of the century geopoliticans and analysts like H.G. Wells believed that the epochal shifts catalyzed by industrialization, increasing interaction density, and the growing power of military technology would require the emergence of world government to prevent eventual catastrophe (Deudney, 2007). Comparable arguments were made by "Nuclear one-worldists" like John Herz, Hans Morgenthau, and Jonathan Schell in the 1970s and 1980s, who believed that nuclear weapons fundamentally undermined the security-provisioning capacities of nation-states in a realm of international anarchy, which required transitioning beyond or at least tempering the institution of state sovereignty to facilitate collective arms control and ensure human survival (Herz, 1957; Morgenthau, 1967; Schell, 2000). While liberal institutionalists like Robert Keohane and Joseph Nye focus on interdependence as a condition of entangled functional interests that creates rational grounds for inter-state cooperation (Keohane & Nye, 1977), other theorists like Deudney, Falk, and the nuclear one-worldists emphasize the dark side of this condition: that it creates systemic pressures towards catastrophic risks in lieu of far-reaching global political-economic transformation (Falk, 1971; Deudney, 2007). Warren Wagar provided an eloquent (and prophetic) articulation of this position in 1967:

> we are in the midst of an immensely complex world revolution. On the one hand, the binding forces and structures of the traditional civilizations have been flung willy nilly into a precarious and premature geophysical unity. And the realization steadily grows of the inevitability, if we survive at all, of an organic world civilization built to the new planetary scale of human life…We are the link between the traditional civilizations of a well remembered past and the emergent world civilization. We stand between. If we break under the strain, there will be no future. All posterity is in our keeping (Wagar, 1967: 6-7, 10).

In short, whether focusing on the inevitability of capitalist breakdown, ecological catastrophe, or an apocalyptic nuclear war driven by the pressures of international anarchy, catastrophist arguments have been a staple, if minority, position in 20th century IR, especially in the past half century. The argument presented in this dissertation can therefore be considered a continuation of this lineage, one that weaves together its multiple threads in a systemic analysis of the contemporary conjuncture – a time when the rumblings of planetary crisis forewarned by these earlier theorists are being experienced with a unique intensity that may signal the imminence of a catastrophic threshold. However, the analysis developed here aims to be more than an updated re-articulation of these earlier approaches. Instead, it will develop a novel theoretical framework that is indebted to these approaches, especially those from the Marxist tradition, and that is able to integrate their insights while developing a more encompassing, synthetic, and dynamic mode of analysis. I will show that this approach can bring greater theoretical traction to the complexity of the contemporary crisis convergence while providing a useful map for individuals, communities, governments, and social movements attempting to navigate its contours.

Of course we must acknowledge that many will perceive the long lineage of catastrophist arguments as itself a sign of the weakness of such arguments. In short (as the common refrain goes): such predictions have never materialized, the apocalypse has been continuously and indefinitely postponed (primarily due to technological ingenuity), and we should therefore be suspicious of "alarmist" claims while affirming the creativity and resilience of existing political-economic institutions (Mann, 2018; Lomborg, 2012; Kelly, 2012). Meanwhile, as the "new optimists" tell us, indicators of "progress" continue to increase around the globe. From this view, propagators of the catastrophist zeitgeist fail to acknowledge and/or realize that life expectancy continues to rise, poverty and hunger are in apparent decline (according to certain metrics), the number of children dying from preventable causes has declined precipitously since 1990, and human health for the majority of the world's population is better than ever (Pinker, 2018; Norberg, 2017). Given such trends, as the new optimists claim, we should not only be more grateful to existing institutions and the power structures that sustain them, but also expect that our collective problem solving capacities, bolstered by "free markets" and democratic institutions, will be more than sufficient to address looming challenges without any sort of catastrophic rupture.

There are many ways to respond to such arguments. Leaving aside debates concerning actual trends in global poverty and hunger alleviation,[5] one can first of all

[5] The 2015 UN Millennium Development Goals report claimed that the poverty rate had fallen from 47% in 1990 to 14% in 2015, while the percentage of world hunger dropped from 23.3% in 1990-92 to 12.9% in 2014-16. However, as Jason Hickel and others show (Hickel, 2016, 2017; Selwyn, 2017; Donnelly, 2019), this provides a misleading picture of both poverty and hunger reduction. First, regarding hunger, 73% of the gains against hunger come from China, most of which occurred in the 1990s (mainly as a result of land reform policies that guaranteed small farmers secure access to land, far from the development recommendations made by the World Bank). Second, the Food and Agricultural Organization (FAO) counts people as hungry only when their caloric intake falls below the "energy requirements for minimum activity levels", which ignores both nutrient and vitamin deficiencies as well as the fact that most workers globally are engaged in active lifestyles. Hickel therefore estimates that, from a more realistic assessment, between 1.5 to 2.5 billion people remain malnourished, which is 2 to 4 times higher than the UN report claims and a vast increase in the absolute number of under-nourished people since 1990 (Hickel, 2016). Regarding poverty, the MDG report, and most optimistic poverty alleviation narratives (e.g. Pinker, 2018), are based on the metric of $1.90 a day, which is widely understood to be far from adequate for supporting basic nutrition and quality of life. Following Peter Edward's "ethical poverty line", Hickel shows that a poverty threshold between $3.38 and $4.88 would mean that poverty has actually increased from 47% to roughly 50% between 1990 and 2017 while *absolute* numbers have dramatically increased (Hickel, 2016: 7). And even this may be considered conservative: former World Bank economist Lant Pritchett proposed that $10 (US) per day should be considered the upper bound of the poverty threshold, which would mean that roughly *88%* of the global population remains in poverty (Selwyn, 2017: 29).

make the obvious point that “progress” (undeniable in some areas, and highly contested in others) is not at all incompatible with imminent catastrophe but is often in fact their very cause (that is, when achieved via an unsustainable fossil fuel-based development model). By cherry-picking statistics abstracted from a systematic analysis of the global conjuncture, these analysts are thus able to invent an optimistic chimera while ignoring or downplaying the environmental and social symptoms of crisis, at best dealing with the later via the deus ex machina of “human ingenuity”. Second, one should note that, the Ehrlichs notwithstanding, many catastrophist arguments, in particular the Club of Rome’s *Limits to Growth* report, anticipated that the threshold of world system crisis would likely not emerge until around 2015 to 2050, and even possibly later depending on policies chosen and unanticipated technological breakthroughs (Meadows et al, 1972; see also Meadows et al, 2004). Thus their predictions have hardly been refuted, and numerous recent studies suggest that we remain squarely on the path they anticipated (Turner, 2014; Jackson & Webster, 2016; Bardi, 2017). Third, these optimistic claims not only fail to systematically analyze the relations and amplifying feedbacks between environmental and political-economic crises, but also ignore how the solutions realized via “human ingenuity” and technological innovation will shift problems around and create new threats. Thus they ignore, for example, how economic stagnation may challenge efforts to address climate change by creating a “growth at all costs” mindset and fueling rightwing populist backlash, or how technological breakthroughs to deal with sustainability challenges will exacerbate catastrophic risks by unleashing cheaper weapons of mass destruction and unprecedented capacities for state securitization (e.g. through biotechnology, nanotechnology, artificial intelligence, and the internet of things). Hence the need for a more comprehensive and synthetic analysis of the "world problematique" as a whole, since solutions must necessarily respond to all problem-domains simultaneously, whereas isolating specific problems will produce solutions that merely shift problems onto other domains (Van den Bergh et al, 2015). The words of William Watts, in his foreword to the original *Limits to Growth* report, continue to ring true to this day:

> It is the predicament of mankind that man can perceive the problematique, yet, despite his considerable knowledge and skills, he does not understand the origins, significance, and interrelationships of its many components and thus is unable to devise effective responses. This failure occurs in large part because we continue to examine single items in the problematique without understanding that the whole is more than the sum of its parts, that change in one element means change in the others (Meadows et al, 1972: 10-11).

As scholars of civilizational collapse like Joseph Tainter have emphasized, it is not simply the existence of challenging individual problems like climate change that can overwhelm societal problem-solving capacities, but rather the simultaneous emergence and synergistic amplification of entwined crises that have brought down powerful states and empires in the past (Tainter, 1988; Harper, 2017). Yet while catastrophist arguments of the past have to some extent been aware of the relations and feedbacks between problems like economic crisis, environmental degradation, resource depletion, and violence, they also have yet to formulate a theoretical framework that can illuminate the qualitative complexity of the "world problematique" and its "solution-space". In large part this is due to the dominance of a positivist modeling tradition based on quantification and simplification of system parameters (what Edgar Morin calls "restricted complexity"), which is ill-equipped to integrate dynamics of power, inequality, and resistance in both its analysis and proposed solutions (Morin, 2006). However, these earlier arguments also didn't systematically consider the relations and feedbacks between environmental degradation and technological change, which left them vulnerable to the arguments of economists and technological optimists.[6] In an age where many proposed "solutions" to climate change and the structural crisis of global capitalism involve technological innovations that are likely to pose catastrophic risks to humanity, it is necessary to approach these seemingly unrelated problem-domains as dimensions of an over-arching "world problematique" (or what I will call the "Planetary Problematic"). This is of course a daunting challenge, and one can only be modest in one's efforts, but I will propose an alternative framework and "methodology" (one whose flexibility and reliance on narrative, intuition, and imagination would hardly count as a "methodology" for most) that is capable of developing the multi-dimensional analysis we need to grapple with our planetary predicament.

The Complexity Turn

The theoretical framework developed in this dissertation can be situated under the broad umbrella of emerging approaches in the social sciences that has been called the "complexity turn" (Urry, 2005). There is a danger that such labels can confuse more than clarify, since it should be emphasized that there is not *one* complexity theory or framework (Cudworth & Hobden, 2011: 13), but rather a loose assemblage of approaches attempting to move past tendencies towards analytic reductionism, disciplinary isolationism, separation between "human" and "non-human" systems, and assumptions of

[6] Certainly many of past analyses understood that technological solutions often gave rise to problems of their own, e.g. nuclear power creating new problems like radioactive waste disposal and the threat of weapons proliferation (Pirages, 1978; Commoner, 1971). But in the contemporary context (with the exception of nuclear power), very few have considered how technological solutions for mitigating climate change while sustaining capitalist growth will create new dangers and potentially catastrophic risks.

linear change and causality that dominate the "Newtonian" scientific worldview (Mitchell, 2009; Prigogine & Stengers, 1984; Kavalski, 2012; Bousquet & Curtis, 2011; Byrne & Callaghan, 2013).[7] As I will elaborate below, my approach to Complexity Theory (CT) will be inspired largely by the philosophies of Gilles Deleuze and Gilbert Simondon, who were among the first the formulate a philosophical ontology that both integrated and anticipated the insights of the complexity sciences (Protevi & Bonta, 2004). From this perspective, CT can be understood as an ontological framework that understands world politics (and the earth and cosmos more generally) as a dynamic mesh of intersecting complex systems, including political-economic, ecological, and technological systems at multiple interpenetrating scales. These systems are constantly co-evolving and morphing as events in the world unfold, and they each exhibit "emergent" properties, behaviors, and tendencies that result from the specific arrangement of and feedbacks between its parts. Rather than closed systems or isolated "substances", complex systems should be understood as open-flow assemblages that "internalize" (or "enfold") all other systems and processes within their planetary (and even cosmic) milieus to some degree. They embody a dynamic and provisional form of stability (which I will call "metastability", following Gilbert Simondon) that is liable to shift between alternative states (or "attractors") in response to external events or slow shifts in critical system parameters (Simondon, 2009). Entities must therefore be

[7] There is a wide range of approaches that often fall under the "Complexity Theory" banner, many of which rely on quantitative modeling and agent-based simulations to understand and predict complex system dynamics (often associated with the Santa Fe Institute), and others that use more qualitative methods and conceptual metaphors to improve our intuitions about a complex world and re-shape the kinds of questions we ask (often associated with the work of Ilya Prigogine and Isabelle Stengers) (Cudworth & Hobden, 2011: 13). These are often distinguished via the concepts of "restricted" and "general" complexity, with the former following a more traditional scientific paradigm that uses the mathematical modeling techniques enabled by chaos and dynamic systems theory, and the latter presenting a deeper challenge to this paradigm but emphasizing radical openness, uncertainty, and the entanglement of knowers with the known (Morin, 2006). As I'll discuss in chapter four, the Deleuzian approach I develop is clearly more on the side of "general" complexity, though the point is not merely to proclaim the superiority of one over the other but to develop a synthesis of both.

understood not in terms of fixed essences but as dynamic processes that are constantly evolving within constraints that are themselves continuously evolving. In this sense, this vision of CT provides a processual ontology in which dynamism and change are the norm, whereas stability and identity are more ephemeral and fragile phenomena that must themselves be explained as emerging from an underlying flux.

There are a number of benefits that CT provides for an analysis of contemporary planetary crisis, though for now I will focus on two. First, CT helps us make the needed shift from the tendency to analyze individual crises or problem-domains towards a more comprehensive, synthetic, and "transdisciplinary" approach. "Complexity", after all, derives from the Latin root *complexus*: what is woven together (Morin, 2006: 2). Once we make the shift towards an analysis of world politics as a mesh of intersecting open systems at multiple scales, it becomes easier to perceive the interwoven nature of dimensions of the "Planetary Problematic" and the feedbacks between them. My approach in this way follows Edgar Morin's injunction to develop new forms of analysis that are adequate for the contemporary conjuncture.

> Since we have been domesticated by our education which taught us much more to separate than to connect, our aptitude for connecting is underdeveloped and our aptitude for separating is overdeveloped… knowing, is at the same time separating and connecting, it is to make analysis and synthesis. Both are inseparable, and our atrophy of the capacity to connect is increasingly serious in a globalized, complexified mode, where it is a matter of generalized interdependence of everything and everyone…We must think the interdependence in all fields, including the complex relation between the parts and the whole (ibid: 21).

Second, CT enables us to make sense of abrupt and nonlinear processes of transformation that rapidly reorganize complex systems into qualitatively novel configurations. In the lexicon of contemporary CT, such processes can be understood as "critical transitions", with the more rapid and discontinuous forms often called “catastrophic bifurcations” (Scheffer, 2009). These events could be understood as nearly synonymous with the concept of “crisis”: turning points when a system can no longer remain in a given state and must “decide” between at least two or more options (Byrne, 1998: 42; Wallerstein, 2004). As I will argue in the following chapters, it is precisely such a situation that the international system finds itself in today, and it is only by weaving together an analysis of its reciprocally determining dimensions that we can anticipate how this crisis might unfold and develop viable responses that go beyond the siloes of individual problem-domains.

While the conceptual tools of CT are vital for developing a theoretical framework for mapping and responding to the planetary crisis convergence, there are important limits to the way it has been utilized thus far in IR and beyond, which are worth highlighting in order to distinguish the approach developed here. First, while there has been extensive discussion regarding the philosophical underpinnings of CT and their capacity to shift beyond the outdated Newtonian assumptions of much mainstream IR (e.g. Kavalski, 2015; Bousquet & Curtis, 2011; Cudworth & Hobden, 2011), IR scholars have yet to deploy the tools of CT to develop an analysis of the planetary crisis convergence and its numerous dimensions, from the earth system crisis to the crisis of capitalism, energy, food, and violence, even though this is arguably the most urgent (and well-suited) task for complexity analysis.[8] Second, there remains much political ambiguity in many of these approaches, or an apparent reticence to situate themselves as analytic components of a political project aiming not simply to understand but also to

[8] The work of Thomas Homer-Dixon (especially Homer-Dixon et al, 2015; also Homer-Dixon, 2006) is an important exception to this tendency, which I’ll review in chapter two.

practically intervene within the mesh of global socio-ecological-technological systems fueling planetary crisis.[9] CT-based approaches have therefore often been critiqued for facilitating a "depoliticizing" agenda that denies our capacities for collective transformation while hearkening us to be modest in our ambitions and adapt ourselves to the uncertainties and unpredictable fluctuations of a complex world (Chandler, 2014; Cooper & Walker, 2011). Third, and related to the second problem, these approaches typically emphasize the role of contingency and unpredictability in complex systems, prioritizing what Edgar Morin calls the pole of "general" over "restricted" complexity (Morin, 2006). In this sense, they tend to counsel the need for modesty and humility in our analytic ambitions and are reticent to make explanatory or predictive claims about the present and future of world politics (Kavalski, 2012; Bousquet & Curtis, 2011; Cudworth & Hobden, 2011). While this is undeniably an important lesson of CT, it can also go too far. In contrast, following Marxists like Alex Williams, Robert Biel, and Immanuel Wallerstein (Williams, 2017; Biel, 2012; Wallerstein, 2004), we can use a combination of "general" and "restricted" complexity approaches – including insights from the earth system sciences, social-ecological systems theory, and Integrated Assessment Models – to anticipate how the future may unfold by mapping rough possibility spaces composed of multiple trajectories. In particular, by identifying large-scale political-economic patterns, the feedbacks between political-economic and earth system processes, and key geological and climactic constraints, we can outline a range of possible future trajectories for the earth and human systems that is open-ended yet constrained, while also

[9] The work of Nick Srnicek and Alex Williams (2015) is a strong antidote to this tendency and constitutes a key inspiration for the framework developed in this dissertation. The explicitly emancipatory CT-inspired approach developed by Erika Cudworth and Stephen Hobden (2011) is also a clear exception.

identifying potential global systemic “tipping points” that may trigger a bifurcation towards alternative trajectories.

These tendencies – towards critique rather than new theory-building, political ambiguity, and excessive analytic humility – mean that existing approaches to complexity in IR are not yet suited to the kind of analysis we need to map or navigate our planetary crisis. While learning from these approaches, I will suggest that it is through an engagement with Marxist political economy, including its heterodox expression in the work of Gilles Deleuze, that CT can best fulfill its potential as a new approach to IR and the social sciences. I will argue that it is at the intersection between CT, Marxism, and Deleuzian philosophy that we can best chart a way forward towards a more comprehensive, synthetic, and systematic analysis of (and response to) the contemporary planetary crisis.

From Marxist Historical Materialism to Deleuzian Planetary Assemblage Theory

Marxism has witnessed a dynamic and much needed resurgence throughout the social sciences in the past decade, catalyzed in large part by the 2007-08 financial crisis as well as increasing recognition of the capitalist drivers of earth system crisis (Anievas, 2010; Harvey, 2010; Foster et al, 2011; Moore, 2015). In a discipline such as IR where the dominant approaches are notorious for being unable to predict much of anything (Kavalski, 2012), it is high time that we revaluate and revamp a theoretical framework that, for all its limitations in the past, has been remarkably prescient in its anticipation of the evolution of capitalist modernity and its tendency towards intensifying crises. From this understanding, we should approach Marxism not as a teleological and economistic reading of history, or a given theoretical framework with a set of pre-established theses, but rather as an open-ended investigation of the past, present and future material-energetic bases of human existence and the structures of political-economic power that organize them (Foster, 2018). In this sense, Marxism and the Historical Materialist tradition grapples with the trans-historical problematic of producing and reproducing individual and collective existence, understanding the modes of power, exploitation, and cooperation through which human subsistence is secured and its relations to the natural world are configured.

The field of Marxist political economy is incredibly diverse and filled with many antagonist approaches, but for the purposes of this dissertation I will focus less on these internal differences than on selectively drawing from those that are most insightful and alive to the conjuncture of planetary crisis in which we find ourselves. In fact, a strong case can be made that Marxist approaches on the whole, especially those within the burgeoning sub-field of "Ecological Marxism", have provided the most productive analyses so far of the contemporary crisis conjuncture. This is because they provide a useful orientation for understanding the contemporary "structural crisis of capitalism" within the *long duree* of capitalist evolution (Wallerstein, 2011; Harvey, 2010; Silver & Arrighi, 2011), emphasize its entwinement with the earth system crisis (Foster, 2013; Moore, 2015), and foreground the emergent structural constraints that a capitalist system imposes on efforts to resolve all dimensions of the planetary crisis, from climate change and resource depletion to poverty and inequality, food insecurity, emerging diseases, and neo-fascist reaction (Foster et al, 2011; Biel, 2012; Robinson, 2014; Venn, 2018). While Marxists are often critiqued for hypostatizing a monolithic entity called "capitalism" as the cause of everything bad, thereby disarming our capacities for more nuanced analyses and interventions (Latour, 2007; Acuto & Curtis, 2013; Delanda, 2016), a more generous and CT-inspired reading suggests that they focus on (and document the structuring effects of) capital as an *emergent agency* that is irreducible to the sum of individual capitalists, markets, and institutions, and which can reasonably be considered the most powerful (distributed) agency on the planet today (given that all nation-states are currently beholden to its endless accumulation, no matter the consequences). Without foregrounding the agency of capital and its emergent tendencies (e.g. its cyclical crises, its imperative to continuously expand at a 2-3% annual compound rate, and its production of increasingly intense inequalities between workers and capitalists, as well as between core and peripheral spaces), we cannot adequately understand the roots of the contemporary planetary crisis or envision adequate solutions that would be in the interest of the human and non-human majority.

However, I will argue that Marxism is both vital yet insufficient on its own for a comprehensive analysis of planetary crisis. I will elaborate the reasons why in chapter three, but for now I will say that Marxist approaches on the whole tend to be limited by 19th century concepts that don't adequately capture the multiplicity of world politics and tend towards uni-dimensional analyses of capitalism as a self-contained or closed system, rather than situating capitalist dynamics within a broader complex systems ontology. Thus they often provide uni-dimensional analyses of the planetary crisis that focus primarily on the crisis of capitalism (e.g. Harvey, 2010; Robinson, 2014; Streeck, 2017; Wallerstein, 2011), at best developing two-dimensional analyses of the crisis of capitalism in conjunction with the earth system crisis (e.g. Foster, 2013; Moore, 2015).

While this goes beyond the majority of existing approaches in IR, it gives Marxists a limited analysis of the multi-dimensional complexity of the planetary crisis convergence and constrains their understanding of how it may unfold in the coming decades.

Yet despite these limitations, Marxism provides a productive foundation from which to expand towards a more comprehensive conjunctural analysis. I agree with John Bellamy Foster when he writes:

> Against attempts in the dominant ideology to characterize Marx as a rigid, dogmatic, deterministic, and closed thinker, it is precisely the open-endedness of his "ruthless criticism of all that exists"…that accounts for historical materialism's staying power. This openness can be seen in the Marxism's ability constantly to reinvent itself by expanding its empirical as well as theoretical content, so as to embrace ever larger aspects of historical reality in an increasingly interconnected world (Foster, 2018).

In this sense, I believe that Marxism can and should continue to expand its theoretical remit to engage in a deeper and more multi-dimensional analysis of the contemporary crisis convergence. I will propose that a synthesis between CT and Marxism, as many Marxist thinkers are already pursuing (e.g. Harvey & Reed, 1996; Biel, 2012; Byrne & Callaghan, 2013; Srnicek & Williams, 2015; Williams, 2017), can contribute most effectively to such a broadened and deepened analysis.

In particular, I will suggest that the philosophy of Gilles Deleuze, including his co-authored work with Felix Guattari, along with the lesser-known work of Gilbert Simondon, provides a productive conceptual repertoire to develop such a synthesis. Despite his philosophical prominence, Deleuze remains a marginal and only selectively understood thinker in the discipline of IR (Lenco, 2014), and it will thus not be obvious to most why he can be turned to for the purposes of developing a multi-dimensional and synthetic analysis of planetary crisis. Most existing engagements with Deleuze selectively draw concepts from his co-authored work with Felix Guattari (e.g. Reid, 2003), and most also associate his work with the "New Materialist" turn (Coole, 2013; Bennet, 2010). Without denying the value of this work, I want to suggest that there is an alternative way to read Deleuze that is more in line with the tradition of Marxism and Historical Materialism. It should be remembered that Deleuze and Guattari were self-proclaimed Marxists who placed the analysis of capitalism front and center in their political philosophy.[10] Yet rather than solely focusing on the problematic of capital, Deleuze and Guattari integrated this analysis within a broader multi-dimensional ontology in which political-economic assemblages emerge from and entwine with non-human forces and structures, from microbes to geological phenomena, technological assemblages, and the earth as a whole. For those familiar with the work of Deleuze and Guattari, it is therefore unsurprising that many have turned to their work for conceptual resources to understand and respond to the condition of the "Anthropocene", since they provide an ontology that "maps the singular dependency of the human species on many layers of material flows from weaponry to order-words, barely held together in a capitalist system currently going into spirals of self-destruction" (Saldanha & Clark, 2016: 434). However, rather than relying solely on Deleuzian and Deleuzo-Guattarian concepts, my approach will follow Manuel Delanda, John Protevi, Eugene Holland and others who demonstrate the kinship between CT and Deleuzian philosophy (Delanda, 2006, 2016; Protevi & Bonta, 2004; Holland, 2011; see also Bousquet & Curtis, 2011). While some may understandably fear that this approach reduces the philosophical depth and intensity of Deleuze's thought (Lenco, 2014), my aim in this dissertation is to

[10] As Deleuze himself stated in an interview, "Felix Guattari and I have remained Marxists, in our two different ways, perhaps, but both of us. You see, we think any political philosophy must turn on the analysis of capitalism and the ways it has developed" (Deleuze, 1997: 171).

develop a selective yet coherent and systematic reading of Deleuze that is primarily intended to develop a framework that can illuminate the contemporary planetary crisis convergence. It is the mark of a great thinker that their depth vastly exceeds the specific uses to which they can be put, and I therefore hardly wish to deny the value of other readings.

Deleuze, Deleuze and Guattari, and their philosophical precursor Simondon will be the subject of chapter four, but for now it is worth elaborating a bit more on how they fit into the project as a whole. On the most general level, these thinkers are useful for providing an ontology of intersecting complex systems that integrates political-economic, ecological, and technological registers, one that privileges dynamism and becoming over being and accounts for abrupt discontinuities in systems and processes. More specifically, we can identify at least four attributes of Deleuzian philosophy that make it useful for an analysis of converging crises. First, Deleuze provides a way for visualizing and thinking about problem-spaces with numerous reciprocally determining dimensions, which he calls (echoing the Club of Rome) a "problematic". Second, Deleuze and Guattari, along with Simondon, conceive individuals at all scales as assemblages that emerge (or "individuate") from a chaotic flux that preexists and impels the individuation of actual entities. This is not only a useful ontology for understanding change and emergence in all kinds of systems, both human and non-human, but also has particular resonance for grappling with the contemporary planetary condition (as I'll discuss below). Third, by emphasizing the reality of multiplicities and assemblages rather than totalizing unities, Deleuze and Guattari help us move beyond the twin poles of a blunt holism (as in certain forms of Marxism) and local interventionism (as in many Foucauldian and Actor-

Network Theory approaches) in order to weave together universality and singularity in a way that can grasp both the singularly local and globally emergent dimensions of the Planetary Problematic. Fourth and finally, Deleuze and Guattari provide what could be loosely called a "methodology" for mapping and interacting with an inexhaustibly complex real; but rather than a fixed methodology, this can be understood as a practice of situating ourselves within the unfolding vectors of a complex and dynamic milieu, mapping its tendencies and feedbacks, anticipating "singularities" (or "bifurcations"), and transforming ourselves along with the world.

Overall, I will argue that a time of "crisis" such as ours requires an ontology that begins from processual flux, maps how individuals emerge from this underlying flux, and contributes to the actual emergence or individuation of novel individuals from this unstable and shifting ground. After all, the time we live in today is one of destabilization and flux, where dominant political-economic systems, institutions, ways of life, and subjectivities are being called into question (Adams, 2016). In the famous words of Antonio Gramsci: "the old is dying and the new cannot be born; in this interregnum a great variety of morbid symptoms appear" (Gramsci, 1971: 276). Our time might also recall Deleuze's simple yet enigmatically mythical phrase: "The world is an egg"; in other words, a "topological space"[11] composed of vectors, gradients, tensions, and thresholds that impels the birth of a new individual (Deleuze, 2004a: 268-269). While Deleuze's "metaphor"[12] applies to being itself, it is perhaps an apt way to conceptualize

[11] In Delanda's terms, a topological space differs from Euclidean space in that it cannot be measured in extensity (e.g. length, width, volume) but is rather like a space folded in on itself, defined by "intensive" dimensions like pressure and temperature, from which actual entities emerge in extension (Delanda, 2006).
[12] In Deleuzian metaphysics, however, it is no metaphor; rather the same "virtual diagram" is being actualized in different registers of being. The philosophically inclined mathematician Rene Thom makes a similar claim when he speculates that the same "catastrophe fold" can be perceived in diverse entities and processes, from embryology to social systems (Thom, 1978).

our 21st century planet earth: a topological space or vector field that is sutured by an imminent "catastrophe bifurcation" (Scheffer, 2009: 18) that will tear apart the relational structure of this world and give birth to new political-economic formations and ways of life – whether "reactive" or "affirmative", beautiful or monstrous (or both). Hence the reality and imminence of "catastrophe", but also the possibility of hope. On a planetary scale we are already witnessing the dissolution of order and the early phases of a period of turbulence and chaos (Arrighi & Silver, 1999; Wallerstein, 2004). Thus the "imperative of individuation" is being thrust upon us, both individually and collectively: the imperative to invent new forms of collectivity, new ways of securing subsistence and regulating political violence, and new ways of relating to ourselves, fellow humans, non-human nature, and the universe. New forms of order, or metastability, at all scales (from the individual subject to communities, cities, nation-states, regions, and the world-system as a whole) will need to be invented, whether in a planned or ad hoc fashion as the planetary crisis convergence deepens over the coming decades. Thus the theoretical framework developed in this dissertation is not meant to be a detached map of an imminent systemic rupture, but rather a dynamic tool in the service of individuals, communities, progressive policymakers, and social movements aiming to navigate the crisis convergence and actualize new worlds in its wake. A theoretical framework inspired by Marxism, CT, and Deleuzian assemblage theory – which I will call "Planetary Assemblage Theory" – can help provide the theoretical orientation we need to synthesize the diverse knowledges and perspectives needed to undertake such an ambitious project. But far from claiming to be totalizing or comprehensive, the goal is more modestly to provide a map that is *more* comprehensive than what has come before, but one that must continue to evolve and accommodate new dimensions and perspectives as the drama of the 21st century crisis convergence unfolds.

Outline of the Dissertation

The dissertation can roughly be divided into three parts. The first chapter will present an empirical overview of the 21st century "planetary crisis convergence". Chapter two will then assess the adequacy of existing IR approaches for understanding this crisis, while chapter three will assess the strengths and limitations of the Marxist tradition. The final part will then present the outlines of an alternative approach. Chapter four will elaborate key concepts from Deleuze, Deleuze and Guattari, and Simondon that form of the basis of "Planetary Assemblage Theory". Chapter five will give a conceptual overview of Planetary Assemblage Theory, while chapter six will apply this framework to develop a synthetic and multidimensional analysis of the contemporary planetary crisis convergence and its "solution-space".

The aim of chapter one will be to provide an over-arching orientation for understanding the complexity of the contemporary planetary crisis convergence (or "Planetary Problematic") and assessing the adequacy of existing approaches in IR and beyond. It will review the key trends in earth system destabilization, global economic instability, energy depletion, and global food crises, and then turn to an analysis of how possible technological solutions to these crises will create potentially catastrophic risks in the realms of nuclear security, biosecurity, cybersecurity, and state securitization. While it will to some extent constitute what I call an "agglomerationist" approach, in that it describes problems in relative isolation from each other, it will also highlight certain relations and feedbacks between these problem-domains. A "properly synthetic" analysis that enables a deeper understanding of our planetary predicament and its multiple possible trajectories will be undertaken in chapter six.

Chapter two will focus on existing approaches within the field of IR and assess their strengths and limitations in grappling with the planetary crisis convergence. It is difficult to structure an engagement with IR around this problematic, since it is not one that has received much attention *as a whole* within the field. Instead, we find more focused engagements with specific dimensions of the Planetary Problematic – whether climate change, energy depletion, economic crises, non-state terrorism, and emerging technological risks – rather than more holistic analyses. However, it is possible to discern common patterns or tendencies within the IR literature on our incipient era of crisis, which I will argue have led the discipline as a whole to under-estimate the severity of emerging crises and ignore the imminence of *catastrophic discontinuity* in political-economic order at all scales of the international system. We can highlight at least four analytical tendencies in this regard. The firstis a tendency towards *biophysical blindness* (or what William Connolly calls "sociocentrism"), which fails to appreciate how world order is built on biophysical foundations, and thus how major changes in the latter will produce irreversible transformations in the former (Connolly, 2017a). The second and third, which characterizes the majority of those who *have* moved beyond biophysical blindness, can be called "isolationism" and "agglomerationism": the tendency to either focus on specific crises and problem-domains in isolation from each other, or to agglomerate insights regarding these various crises without systematically articulating their relations and feedbacks. Overall, I will argue that these analytic tendencies often generate conclusions that are “continuationist”, in the sense that they assume the basic contours of the global political-economy are sufficient to resolve 21st century challenges and will continue indefinitely in its present (i.e. liberal capitalist) form. Finally, we can perceive a tendency among certain critical approaches towards “discourse-centrism”: the tendency to focus on how crises are discursively articulated and addressed by hegemonic security and economic agencies in practice but without engaging with their biophysical reality. To illustrate these tendencies, I will first focus on the emerging literature regarding the “crisis of liberal internationalism” and the future of world order as an exemplary illustration of biophysical blindness and continuationism. Second, I will engage with the literature on global environmental politics and environmental security as illustrative of tendencies towards isolationism and agglomerationism. Third, I will engage with the Foucauldian literature on security and resilience to illustrate the problem of discourse-centrism. I will conclude by suggesting that the recent “Planet Politics” manifesto, along with incipient forays into CT and “Posthumanism”, provide the makings of a more adequate approach that moves beyond the above tendencies, though I will argue that an engagement with the Marxist tradition is needed to deepen their engagements with the planetary crisis convergence.

Chapter three will provide an overview and evaluation of Marxism in IR and beyond. I will first provide a broad overview, and will then focus on the sub-traditions of Neo-Gramscianism, World-Systems Theory, Ecological Marxism, and Daniel Deudney’s “Historical Security Materialism”. I will argue that these approaches within the realm of Marxist Historical Materialism are most alive to the conjuncture of planetary crisis in which we find ourselves, and are therefore a useful foundation to build from. However, I will claim that they remain overly circumscribed in both their ontological and analytical horizons, which is largely due to a tendency to focus on global capitalism as a totality rather than embedding the analysis of capitalism within a broader complex systems ontology. I will argue that this limits their grasp of the multi-dimensional nature of the planetary crisis, the contours of its (spatiotemporally uneven) solution-space, and the problem of transitioning beyond crisis towards new ways of life and a new world-system. One way to move beyond these limitations, I will suggest, is to integrate the insights of Marxism within a broader complex systems ontology, one influenced by the philosophies of Deleuze and Simondon along with recent work in CT, which will be the object of the following chapter.

Chapters four will elaborate key concepts from Simondon and Deleuze, which will be used in chapter five to elaborate the conceptual foundations of Planetary Assemblage Theory. I will first provide a conceptual overview of Deleuze and Simondon's philosophies, focusing in particular on the concepts of "individuation" and the "problematic", and will then show how they can be brought into productive engagement with recent work in CT – particularly on the concepts of resilience and catastrophic bifurcations. Next, I will elaborate key concepts from Deleuze and Guattari that will inform the "methodology" utilized in subsequent chapters, including the concept of the assemblage, the capitalist axiomatic, mapping, and minor science. Chapter five will then sketch an overview Planetary Assemblage Theory, which conceives planetary politics in terms of an over-arching "Planetary Assemblage" that is itself a multi-scalar constellation of symbiotic socio-ecological, cognitive-affective, and military-security assemblages (rather than conceiving capitalism as a "totality" in relation to which ideological and state-forms are "superstructural"). I will suggest that each sub-assemblage of the Planetary Assemblage forms a "solution" to a relatively autonomous problematic: including the "Socioecological Problematic" (SEP): the problem of producing and reproducing a society's material needs; the "Molecular and Molar Violence Problematic" (MMVP): the problem of simultaneously constraining "molecular" (local and small-scale, relative to the gaze of the state) and "molar" (state) violence; and the "Existental Problematic" (EP): the problem of creating meaning and orientation in a vast inhuman universe. However, it will show how these problematics are fundamentally entangled such that solutions to one will necessarily shape the problematic and solution-space of the other. The chapter will then discuss how this approach relates to and differs from both the Club of Rome's "World Problematique" and contemporary forms of Integrated Assessment Modeling by contrasting it with the "methodology" of "Synthetic Crisis Mapping".

Chapter six will then deploy Planetary Assemblage Theory to analyze the Planetary Problematic and its "solution-space". The chapter will show why and how the converging crises in the SEP will likely produce a "terminal" crisis of neoliberalism in the coming years, and quite possibly a terminal crisis of capitalism in the next few decades. More specifically, it will argue that the overall Planetary Problematic leaves the world-system with three general potential pathways (each with multiple possible iterations): 1) a Green Neo-Keynesian world-system that redistributes political-economic power and tries to create a more ecologically sustainable basis for continued economic growth through technological innovation; 2) an "Ecosocialist" world-system that subordinates the world market to democratic planning at multiple scales and transitions beyond growth to a steady-state political-economy; or 3) a spatiotemporally uneven world-system "collapse", which I will argue is almost assured if neoliberalism remains hegemonic. The chapter will then show how the Green Neo-Keynesian solution is likely to provoke a systemic rupture in the MMVP by generating self-reinforcing feedbacks between structural, molecular, and molar violence, thus creating a "Planetary Techno-Leviathan" with unprecedented surveillance and force mobilization capacities. I will then briefly consider the MMVP for a low-throughput ecosocialist transition scenario, which would likely be more tractable due to its reduced dependence on dangerous technologies and lower intensity of structural violence, though it would still pose challenges that could tip it into an authoritarian attractor.

Overall, the analysis of chapter six will show that the contemporary world-system is mired in a genuine *predicament*: a complex configuration of "wicked problems" with no simple or unidimensional solutions, since solutions to individual problems in isolation will give rise to unexpected challenges by shifting problems into other domains (Ritchey, 2011). However, a sufficiently "radical" analysis – one that illuminates the political-economic and ontological roots of the planetary crisis convergence –demonstrates the potential for post-capitalist global solutions – based on ecosocialist "degrowth" in the global north and "convergence" with the global south – that can address all dimensions of the Planetary Problematic with minimal problem-shifting. This is not to say they that an ecosocialist world-system would be a utopian world free of problems and struggles, but simply that the challenge of actualizing an alternative world-system that is able to ensure a good quality of life for all humans (and many non-humans) within environmental constraints is *not* insoluble (though such solutions are indeed improbable). The judgment of Thomas Princen converges with this dissertation's conclusion:

> There are other paths with slopes not so treacherous that offer possibilities for stability, security, and fulfillment. Those paths, at once gentler and more manageable, challenging and more fulfilling, offer a good life, albeit with a lot less power, with a lot less material and energy. But unlike the 'gotta move forward' path of material progress…these other paths require hard choices, the willingness to sacrifice, to exercise restraint, to say no, to think long term (Princen, 2010: 16).

While progressive trajectories based on material-energetic degrowth, redistribution, and political-economic democratization are not impossible, I will also emphasize that we should not solely focus our efforts on these outcomes (what I call the "revolution or bust" approach). Instead, the conclusion will elaborate on what I call a "navigational" understanding of counter-hegemonic agency (Srnicek & Williams, 2014), which is both an approach for grappling with global complexity and a conception of praxis where the goals of counter-hegemonic agency evolve as opportunities arise and dissipate. For example, a time may come (if it hasn't already) when we should rationally conclude that a global collapse in some form is inevitable, at which point we should prioritize collapse preparation, relocalization, and harm reduction. In this sense, following Deleuze's stoicism, we do our best to enhance our collective power and joyous affects in the midst of political-economic and planetary turbulence, which is not only a problem to be solved but a condition to be lived out and affirmed to the best of our ability. In this way, the dissertation will end by reflecting on the productive tension between hope and pessimism in responding (intellectually, emotionally, and practically) to our planetary predicament.

Chapter One: The Planetary Crisis Convergence

This chapter will provide an overview of several key dimensions of the 21st century planetary crisis convergence, or what I will later call the “Planetary Problematic”. To some extent it will take the form of what I call an “agglomerationist” analysis, in the sense that it details each dimension of the crisis in relative isolation from the others, but it will also illustrate key connections in order to clarify the predicament it constitutes and the constraints it imposes on the possibility space of any future world order. Thus the goal of this chapter is to lay out the broad empirical contours of the planetary crisis convergence in order to make clear the limits of existing approaches in IR and beyond, which will be assessed in chapters two and three. Chapter six will then rearticulate the problematic using the conceptual tools of Planetary Assemblage Theory, which will analyze the reciprocal relations and feedbacks that form what could be called a “virtual architecture of global crisis” (Homer-Dixon et al, 2015), identify potential crisis “triggers” and cascades, and provide a rough mapping of the global (yet geographically uneven) “solution-space”.

Before plunging into the dimensions of the planetary crisis convergence, it is worth briefly reflecting on the meaning of “crisis” at work in the analysis. The chapter speaks of an “earth system crisis”, a “structural crisis of global capitalism”, a “global energy crisis”, and a “global food crisis”. We might also speak of a looming “crisis of violence interdependence” (following the analysis of Daniel Deudney) (Deudney, 2007). My use of the term “crisis” will become more clear in chapters four and five where I discuss concepts from Deleuzian philosophy, Complexity Theory, and the framework of Planetary Assemblage Theory. But for now I will say that “crisis” does not merely signify a localized spatiotemporal event or "shock" with detrimental implications for political-economic stability and human (and non-human) well-being. Rather, it expresses a *looming bifurcation*, or a situation in which things can no longer go on as they are. As James O'Connor describes, "crises" were understood in Ancient Greece as "moments of truth when the significance of men and events were brought to light", or "turning points" in which the necessity of *decision* is thrust upon us (O'Connor, 1981: 301). In the more formalized language of complexity theory, a crisis can be understood as a "critical transition" in which a system exits a stable formation and enters a turbulent phase transition in which the structures, functions, and feedbacks that define the system are ineluctably transformed (Scheffer, 2009: 104). In this sense, all the "individual" crises discussed in this chapter are situations where a given systemic configuration has reached (or will soon reach) the limits of its viability and is in process of giving way to something new. Together they form a convergence of crises – or "crisis multiplicity" (neither one nor several) – that is more than the sum of its parts (George, 2010), though we must begin by understanding its key dimensions.

I will begin with an analysis of the earth system crisis through the concept of "planetary boundaries", with particular emphasis on climate change as a key parameter. I will then shift to an analysis of the structural crisis of global capitalism, which will include an overview of both the key political-economic tensions it confronts as well as the constraints that the earth system crisis imposes on efforts to restore long-term capitalist growth and stability. I will then explore the global energy crisis with particular attention to what is often called "peak oil" as well as the probable (though uncertain) biophysical limits of renewable energy. Next, I will give an overview of looming stressors and contradictions in the global food system, which maintain 1 to 3 billion people within "undernourished" conditions (depending on how one defines "undernourishment"), have already provoked food riots (in 2008 and 2011), and threaten to unleash further catastrophes in the coming decades. Finally, I will consider how technological innovation may mitigate the severity of the above crises, as many techno-optimists hope, though rapid technological innovation would create new powers of destruction in the realms of nuclear security, biosecurity, and cybersecurity, alongside unprecedented capacities for surveillance and securitization by states.

The Earth System Crisis

To start, we can conceive of the earth system as the broadest level of the overall crisis convergence, which encompasses the dynamic interaction between the earth's atmosphere, the oceans, the biosphere, the cryosphere, and the lithosphere. Whereas some still think of the earth as a collection of autonomous systems and processes, earth system science heralds a paradigm shift in which the earth comes to be understood as having "emergent properties" that require us to study it as a whole. As Clive Hamilton explains, earth system science must be understood as "the integrative meta-science of the whole planet as a unified, complex, evolving system beyond the sum of its parts" (Hamilton, 2016: 94). Earth systems science in this way follows in the footsteps of Gaia theory by emphasizing the self-regulating properties that help maintain the earth's key parameters within conditions conducive to biological flourishing (Lovelock, 2000), which include temperature range, geochemical balances between the surface and atmosphere, and forms of biodiversity, though historically it has been shown to rapidly shift between different states.[13] As Will Steffen and colleagues write,

> The behaviour of the Earth System is typified not by stable equilibria but by strong non-linearities, whereby relatively small changes in a forcing function can push the System across a threshold and lead to abrupt changes in key functions (Steffen et al, 2005: 71).

For the past ten thousand years the earth has been in a uniquely stable state characterized by consistent temperatures, freshwater availability, and biogeochemical fluxes between the atmosphere and marine and terrestrial ecosystems, called the "Holocene". While the Holocene climate has itself varied in response to orbital, solar, and volcanic forcings, with significant implications for human development and survival,[14] these fluxes remained in a fairly consistent bandwidth that on the whole has been conducive to agriculture and the development of complex agrarian (and later industrial) civilizations. The "Anthropocene", then, marks the beginnings of a regime shift beyond the Holocene catalyzed by human perturbation of the earth's system's regulatory mechanisms, particularly through the extraction and release of fossilized carbon into the atmosphere (Crutzen & Steffen, 2003; Malm, 2016).

One of the most useful frameworks developed so far for grappling with the implications of earth system change for political-economic development is the concept of "planetary boundaries" (PB). As Rockström and Wijkman explain, the PB framework

[13] As planetary scientist Will Steffen and colleagues argue, the existence of planetary scale critical transitions can be observed in the 420,000 year data from the Vostok ice core, which shows a close correlation between climate shifts and changes in the global carbon cycle across the planet (Steffen et al, 2005: 3). This is seen particularly in the periodic shifts between glacial and interglacial states, cold and warmer periods, over the past several hundred thousand years (Scheffer, 2009: 149).

[14] E.g. the "Medieval warm period" and "little ice age" that followed, as well as the "Roman Climate Optimum" conducive to Roman expansion and the "Late Antique Ice Age" that contributed to its fall (along with the decline of Han dynasty China) (Fagan, 2009; Harper, 2017).

emerged as a collective effort encompassing scientists working in the fields of systems ecology, resilience theory, and sustainable development, whose main aim was

> to define the biophysical processes that are crucial for a stable development on Earth, and, on the other hand, to determine the risk of threshold effects relative to these processes and identify [their] key drivers (Rockström & Wijkman, 2012: 44).

As Rockström et al explain, planetary boundaries represent judgments on the value of key control parameters in the earth system deemed to be a "safe" distance from dangerous levels. Whereas *thresholds* refer to inflection or tipping points at which feedback mechanisms produce nonlinear transformations away a previous state, *boundaries* on the other hand are more like "guard rails" set a distance from these estimated thresholds, which are judged based on an "ethical time horizon" such that political decisions could be taken in time to avoid the threshold after a boundary is crossed (Rockström et al, 2009a). Rockström and colleagues identify nine boundaries, which encompass key control variables in the earth's biogeochemical cycles, circulation systems, and biophysical features that contribute to the earth's overall self-regulating capacity. These include climate change, rate of biodiversity loss, interference with the nitrogen and phosphorous cycles, stratospheric ozone depletion, ocean acidification, global freshwater use, change in land use, chemical pollution, and atmospheric aerosol loading (Rockstrrom et al, 2009b: 472).[15] For each of these processes Rockström et al quantitatively estimate values at which gradual changes may begin to accelerate through feedbacks based on historical

[15] The PB framework has been criticized for positing planetary-scale boundaries for largely regional processes and thereby obscuring geographic unevenness (Brook et al, 2012), for exaggerating the constraints on human development imposed by boundaries and the need to remain within Holocene-like conditions (Nordhaus et al, 2012), and for hypostatizing social constructs as real entities that ignores regional variation in climate change impacts and adaptive capacity (Palsson et al, 2013). Rockström et al respond to the first point by claiming that while not all the boundaries have singular thresholds at a global scale (e.g. land-system change, freshwater use, biodiversity loss, and changes in biogeochemical flows), these processes likely possess local and regional thresholds that can generate feedbacks to the processes (mainly climate change and ocean acidification) that do have large-scale thresholds (Steffen et al, 2015: 2).

data on similar nonlinear changes in the past. While each boundary plays an important role in earth system stability, Steffen et al argue that climate change and biosphere integrity form the key boundaries with the most influence over the earth system as a whole. They write:

> climate change and biosphere integrity—are highly integrated, emergent system-level phenomena that are connected to all of the other PBs…They are regulated by the other boundaries and, on the other hand, provide the planetary-level overarching systems within which the other boundary processes operate…large changes in the climate or in biosphere integrity would likely, on their own, push the Earth System out of the Holocene state (Steffen et al, 2015: 6-7).

Recent analyses suggest that the earth system has already crossed at least four planetary boundaries – climate change, biodiversity loss, land-use change, and nitrogen and phosphorous loading – which means we are likely approaching (if not already crossing) a threshold of irreversible transformation and "collapse" for many local and regional ecosystems (Raworth, 2017). While there is great debate and uncertainty about the severity of what is often described as the current "sixth mass extinction" (due to uncertainty about the total number of species on earth and limited data on species declines in many regions), a broad survey of the evidence suggests that the global rate of species extinction "is already at least tens to hundreds of times higher than it has averaged over the past 10 million years" (IPBES, 2019: 3). An estimated 11,000 to 58,000 thousand species may be going extinct annually, including 10 to 500 species of fungi, bacteria, plants and insects going extinct every day, with deleterious consequences for ecosystem functioning, agriculture, and climate change (Dirzo et al, 2014).[16] A group

[16] Rodolfo Dirzo and colleagues note that key ecosystem functions and services that depend on resilient biodiversity include pollination, pest control, nutrient cycling and decomposition, water quality and human health. Biodiversity loss can therefore reinforce ecosystem collapse that in turn reinforces climate change by turning carbon sinks into net sources (especially in the Amazon and other tropical regions where biodiversity loss is most severe). Dirzo et al warn that these trends, which they call "systematic defaunation", threaten "to fundamentally alter basic ecological functions

of 59 scientists in a World Wildlife Fund report estimate that 60% of mammals, birds, fish and reptiles have been wiped out since 1970 (World Wildlife Fund, 2018). The rate of extinction is even faster for insects – eight times the rate of mammal, bird and reptile extinction – with total insect mass falling 2.5% per year and possibly on pace to completely vanish within a century (Sanchez-Bayo & Wyckuhs, 2019).[17] In the realm of marine biodiversity, which intersects with ocean acidification, about a third of fisheries across the globe are on the brink of collapse, while some scientists estimate that we're nearing the threshold of large-scale oceanic anoxic event in which levels of acidification provoke widespread extinction of marine life (Chu, 2019).

Regarding the land-use boundary, scientists estimate that over 75% of the Earth's land area is already degraded and could reach 90% by 2050 (Joint Research Centre, 2018), while 18.7 million acres of forests are being lost annually (equivalent to 27 soccer fields per minute) (World Wildlife Fund, 2019). Some scientists argue that "zero future land conversion of natural ecosystems into farmland" will be necessary to reverse deforestation, biodiversity loss and greenhouse gas emissions (Willet et al, 2019: 23). Yet deforestation has only accelerated since 2015, despite Paris agreement efforts to reverse the trend. As a result, multiple studies estimate that tropical forests around the world are becoming net carbon sources rather than sinks (Baccini et al, 2017; Tagesson et al, 2020; University of Leeds, 2020). Furthermore, the Amazon rainforest – the oft-noted "lungs of the earth" and vital storehouse of biodiversity – may be nearing a "point of no return"

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and is contributing to push us toward global-scale "tipping points" from which we may not be able to return" (Dirzo et al, 2014: 405).

[17] There is debate on whether insect declines are a global phenomena or limited to certain regions, with some arguing that the "insect apocalypse" narrative has been overplayed (Saunders et al, 2020). A meta-study compiling data from 166 surveys performed at 1,676 sites worldwide found an average decline of 0.92% per year of terrestrial insect populations, though it reported increases in some freshwater insect populations (Van Klink et al, 2020). This suggests that we are indeed facing alarming levels of insect declines across the planet, though the researchers emphasize that much uncertainty remains and more data collection is needed.

beyond which positive feedbacks will push it towards a non-forest ecosystem (Lovejoy & Nobre, 2018).

The Climate Crisis

This brings us to the climate boundary, which is being primarily stressed by fossil fuel combustion and will be further exacerbated by stress on other planetary boundaries (particularly biodiversity and land-use). The international policy consensus is that warming must be limited to an average rise of 1.5-2°C above pre-industrial levels to avoid catastrophic climate change. Given the geographical and "intersectional" unevenness of climate impacts (i.e. their unevenness with regard to geographic and race-class-gender position), we should be wary such universal markers as supposedly "safe" limits (Sealey-Huggins, 2017). For example, the goal of 2 degrees is considered by many to be a "death sentence" for low-lying island nations as well as millions in Africa, Asian, and Latin America (Angus, 2016: 96), and the recent IPCC report estimates that the number of people vulnerable to lethal climate impacts will be higher by "several hundred million" in a 2°C relative to a 1.5°C world (IPCC, 2018: 11). Still, it is important to recognize the likely existence of global thresholds at which positive feedback loops may catalyze an irreversible process of runaway climate change. In particular, planetary scientists like Johan Rockström, Will Steffen, Hans Schellbhuber and others consider 2°C as the likely point beyond which the earth system would enter a "Hothouse Earth pathway", defined as a state where

> biogeophysical feedbacks in the Earth System…[would] become the dominant processes controlling the system's trajectory… raising the temperature further to activate other tipping elements in a domino-like cascade that could take the Earth System to even higher temperatures (Steffen et al, 2018: 3).

Unfortunately, leading states have to date woefully failed to put the world economy on track to prevent a 2°C or more increase. The 2015 Paris Agreement explicitly aims to keep climate change "well below 2°C", though the voluntary "Nationally Determined Contributions" on which it is based put the planet on a path of at least 3 to 3.4 °C of warming by 2100 (which is likely conservative) (Steffen et al, 2018).[18] Carbon pricing (increasingly understood to be a necessary but insufficient mitigation strategy) only covers about 20% of world-wide fossil fuel consumption; worse, "less than 1% of global carbon emissions are subject to a price that economists peg as high enough [i.e. at least $40 per ton] to meaningfully curb them" (Ball, 2018: 2492). Instead, the dominant mitigation strategies so far involve little more than what Patrick Bond describes as a mix of "shifting, stalling, and stealing" – shifting emissions reductions onto the global south through carbon offset markets, delaying the need to invest in more transformative infrastructures, and stealing land from peasants across the global south for biofuels or reforestation projects that win carbon credits (Bond, 2012: 68).[19] Furthermore, a 2019 UNEP report showed that "countries' planned fossil fuel production not only exceeds 1.5°C and 2°C pathways," but also exceeds levels consistent with the implementation of their (already inadequate) pledges under the Paris Agreement

[18] With a higher climate and earth system sensitivity figure that takes into account carbon-cycle feedbacks, including releases of carbon and methane from degraded soils, forests, and ice albedo, an MIT study claims that the Paris path could lead to approximately a 5°C rise, though the median figure is 4°C (Reilly et al, 2015; Spratt & Dunlop, 2017). The potential for a 5°C rise even on our current policy trajectory is reinforced by recent modeling evidence showing a higher climate sensitivity (up to 5.6°C in several models, compared to a previous upper end of 4.5°C), though the implications of these models are disputed (Hood, 2020).

[19] To worsen matters even more, states are still struggling to agree on the basics of governing these woefully inadequate carbon markets, with states like Brazil, Australia, and the US trying to leave loopholes open that would further undermine their effectiveness. In particular, these states (among others) are stifling negotiations by fighting to 1) allow emissions reductions from carbon offsets to be double counted (i.e. counted as reductions in both the buyer and selling states); and 2) allow older carbon credits from the Kyoto Protocol to be traded on the new market, which would flood the market with credits from projects with dubious climate credentials (Farand, 2019b). The implications for climate governance are significant. As Kevin Levy from the World Resources Institute says: "how these rules are decided is really going to make or break the ambition of the Paris Agreement" (quoted in Farand, 2019b).

(UNEP, 2019: 4), and the majority of states have so far refused to adopt more ambitious targets and change their production plans accordingly (Farand, 2019a). This means that current policies may actually be putting us on pace for four and possibly more degrees of warming by the end of the 21st century, which Kevin Anderson argues would be "incompatible with an organized global community…likely to be beyond 'adaptation'…devastating to the majority of ecosystems, and has a high probability of not being stable" (quoted in Spratt & Dunlop, 2017: 14).

The earth is already witnessing dangerous impacts at the current average of a 1°C rise, seen in accelerating polar ice melt, intensified hurricanes, flooding, wildfires, drought, and increasingly lethal heatwaves. One study estimates that a 1.5°C scenario, which could be reached as early as 2030 (Xu et al, 2018), would leave 16% of the world's population exposed to potentially lethal climate impacts, which would rise to 29% (2.7 billion people) in a 2°C scenario, and up to 50% of the population (4.6 billion people) in a 3°C scenario (Byers et al, 2018). Beyond this, a 4°C world likely be "beyond adaptation" for much of the global population, especially in Africa, the Middle East, and Southeast Asia, which would be regularly subject to sigma-3 and even sigma-5 heat waves (Angus, 2016: 97-98; UNEP, 2015). The impact on food production may be catastrophic, with wheat and maize losses exceeding 50% on average for large parts of tropical land areas, and perhaps yield reductions of up to a third globally (though there is immense uncertainty regarding such projections) (Angus, 2016: 102; Cribb, 2019).

These numbers make it clear that, in the words of Climate scientist Kevin Anderson, "2°C represents the threshold between dangerous and *extremely* dangerous, rather than between acceptable and dangerous climate change" (Anderson, 2012: 19-20).

However, since we are dealing with massively complex systems with disproportionality between causes and effects, there is great uncertainty with regard to the precise speed and scale of future warming – seen in ongoing debates regarding the "equilibrium climate sensitivity"[20] – and its likely impacts. Mainstream climate science, represented by the IPCC, adopts a primarily "gradualist" approach that projects between 3 and 3.4 °C by 2100 and downplays the risk of more extreme scenarios (IPCC, 2014; see also Hausfather & Peters, 2020). However, as Naomi Oreskes and colleagues demonstrate, IPCC projections "have systematically underestimated key climate change drivers and impacts", which they attribute to the tendency among scientists of "erring on the side of less rather than more alarming predictions" (Oreskes et al, 2013: 327-328). It is therefore reasonable to consider more extreme scenarios (e.g. 4°C or more by 2100) to be, at the very least, more likely than commonly understood, and research continues to indicate the likelihood of powerful carbon-cycle feedbacks that may push us towards a hothouse earth pathway (Steffen et al, 2018; Lenton et al, 2019). For example, as previously noted, evidence suggests we are already passing tipping points in the capacities of tropical rainforests worldwide to absorb carbon, with one study predicting that the Amazon will become a carbon source in the mid-2030s – "decades ahead of even the most pessimistic climate models" (University of Leeds, 2020). Climate scientists also fear that the transition to renewable energy may add up to 0.7°C of additional warming by

[20] The IPCC has traditionally assumed a equilibrium climate sensitivity of between 1.5 and 4.5 degrees C. However, at least eight of the global-scale models used by the IPCC to develop their sixth assessment report are showing upward trends in climate sensitivity (Hood, 2020; Henson, 2019). This may be due to modeling advances that are better able to integrate the effects of cloud cover and aersol emissions, which seem to suggest that changing cloud cover will play more of a positive than negative feedback role on warming. The implications of these models are being disputed, though as Johan Rockström says: "You have to take these models seriously – they are highly developed, state of the art" (quoted in Hood, 2020).

neutralizing the "shield of aerosols" that results from fossil fuel combustion (Xu et al, 2018), though others challenge this perspective (Toll et al, 2019).

Perhaps most importantly, while there is immense debate and uncertainty, studies suggest that the risk posed by carbon and methane release from both sub-sea and terrestrial methane sources – which contain more than thirteen times the CO2 equivalent currently held in the atmosphere – has been under-estimated by mainstream climate science (Wadhams, 2017; Farquharson et al, 2019; Neumann et al, 2019; Lamarche-Gagnon et al, 2019).[21] For example, arctic ice expert Peter Wadhams suggests that the loss of arctic sea ice will likely accelerate the melting of sub-sea methane hydrates by removing the "air conditioning layer" that previously kept arctic waters close to 0°C (Wadhams, 2017: 123). This could unleash an abrupt "pulse" of 50 gigatons from the shallow East Siberian Shelf that rapidly raises global temperatures by 0.6°C, which would "speed up all the other global warming effects", "bring forward by fifteen to thirty-five years" the date at which the global temperature increase exceeds 2°C (getting us there between 2035 and 2040), and potentially unleash a chain reaction of further hydrate collapse and methane release (ibid: 125-126). The terrestrial permafrost poses a more long-term threat, though recent studies show that it is already thawing much faster than IPCC models anticipate due to "abrupt thawing" events associated with thermokarst lakes (Farquharson et al, 2019), which "may mean an influx of permafrost-derived methane into the atmosphere in the mid-21st century, which is not currently accounted for

[21] The risk posed by methane has been a source of tense debate between climate "catastrophists" and more mainstream climate scientists. The IPCC fifth assessment report concluded that it was "very unlikely" that a catastrophic methane release could occur this century (IPCC, 2014: 1116), and the 2018 IPCC report excludes methane from its projected carbon budget (IPCC, 2018). These conclusions are supported by Michael Mann, who argues that methane release will be "small compared to human emissions" of carbon (quoted in Cribb, 2019). In contrast, Natalia Shakhova and colleagues show that methane "clathrates" in the sub-sea permafrost are already venting significant quantities of methane, though it is unclear whether this is a steady ongoing phenomenon or the sign of a more recent accelerated release trajectory (Shakhova et al, 2010; for more recent evidence see Davidson, 2019).

in climate projections” (Gray, 2018). Furthermore, another study suggests that increased precipitation in the arctic driven by higher temperatures will speed up permafrost melt even more (Neumann et al, 2019), while another suggests that ice-sheets, which are currently ignored in global methane budgets, may contain significantly more methane than previously thought (Lamarche-Gagnon et al, 2019). In sum, it is impossible to say with any certainty what the risks are, and we should not conclude that the most extreme “methane bomb” scenarios are the most likely to materialize (though neither should they be discounted) (Wadhams, 2017). Yet we are likely to face significant carbon and methane seepage from under-sea and terrestrial permafrost over the course of this century and beyond that would make runaway warming difficult if not impossible to reverse if we cross the 2°C threshold.

Overall, the looming climate emergency is the greatest threat confronting humanity and the earth system. Human consumption may *already* exceeding the earth’s biocapacity by 150% (according to ecological footprint analysis), with wealthy populations in the United States consuming an average of 7.2 hectares per person (relative to 1.5 hectares per person in Africa and 4.5 in Europe) (Dauvergne, 2016: 58)[22], and this already-stretched biocapacity would be further degraded (if not decimated) by climate chaos. With a growing population striving to attain the levels of material consumption practiced in the global north (and which practically all governments,

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[22] Ecological footprint analysis estimates that, given an overall biocapacity of around 12,000 hectares (which might be an optimistic estimate), a “fair share” for each human on the earth would come out to about 1.6 hectares per person, which approximates current levels of consumption in Africa (Dauvergne, 2016: 58). Eco-footprint analysis is not without flaws as a metric for gauging sustainability, since it aggregates multiple types of resources (e.g. land, water, air) into a single indicator that ignores qualitative differences. Others, particularly ecomodernists, argue that claims regarding a finite biocapacity (or “carrying capacity”) for the earth as a whole are exaggerated, which they believe can be indefinitely raised or surpassed via technological innovation (Nordhaus, 2018). Yet others believe that eco-footprint analysis actually *underestimates* overall impacts and may therefore *overestimate* the earth’s biocapacity (Richardson, 2018). We should thus not take such estimates as objective fact but rather as useful tools to gauge the overall (un)sustainability of present consumption patterns.

mainstream economists, and corporate elites across the planet expect to be realized) and an earth system already on the brink of catastrophic thresholds that would further shrink its capacity to support human and non-human life, it requires a hefty dose of techno-optimistic faith to envision a future that doesn't involve a precipitous discontinuity in this trajectory (before even taking into account the numerous other dimensions of the planetary crisis convergence).

The Structural Crisis of Global Capitalism

As the earth system enters a prolonged phase of turbulence and potential collapse, so has the capitalist world economy – itself the primary driver of earth system crisis – entered a prolonged era of turbulence and stagnation. Most Marxists, as well as many non-Marxist economists, agree that capitalism has been mired in a long-term "structural crisis" (often called "secular stagnation") driven by a combination of diminishing outlets for profitable investment, unprecedented inequality and stagnant wages that limit effective demand while relying on credit-fueled consumerism, the funneling of surpluses into speculation instead of production, and global trade imbalances between debt-fuelled consumer countries (especially the United States) and creditors (especially China and Germany) (Harvey, 2010; Summers, 2016; Gordon, 2017; Galbraith, 2014; Wolf, 2014).[23] Global GDP growth has declined from a rate of 5.5% in 1967 to 2.5% annually

[23] It is worth noting that some see "secular stagnation" as a rich world phenomena from which "emerging markets" like China and India appear to be relatively immune. While this is true to some extent, numerous analysts make clear that there are major problems with disaggregating the global economy in this way. While slowdowns in GDP growth are undoubtedly more significant in the US and Europe, emerging markets are highly vulnerable to shocks in these countries resulting from decreased demand for exports and higher costs for financing their dollar-denominated debts (e.g. in the case of interest rate hikes by the US Federal Reserve) (Wolf, 2014: 100; J Smith, 2016; McChesney & Foster, 2013; Tooze, 2018). Meanwhile, China's relative economic strength in the decade following the financial crisis was largely due to a massive stimulus and credit expansion, bringing its public and private debt from 120% in 2008 to 257% of GDP in 2017 – hardly a sustainable trajectory (Foster & McChesney, 2013: 158). And if China enters a deep recession so will much of the developing world, due to its reliance on Chinese demand for raw material imports. Hence

in 2016 (Jackson, 2018: 6-7), growth has itself become vastly more reliant on debt – rising from around 100% to 250% of GDP between 1965 and 2018 (IMF, 2018), and the benefits of that growth have been disproportionately shared – with 27% of total growth since 1980 going to the richest 1% (a trend that has only gotten worse since 2008) (Alvaredo et al, 2017).

The 2007-08 "Great Financial Crisis" (GFC) itself signaled the breakdown of an unsustainable debt-financed growth trajectory, which was propelled in particular by a housing boom in the United States that relied on innovative and opaque financial instruments (e.g. Mortgage-Backed Securities that pooled together different classes of mortgage debts, Collateralized Debt Obligations that repacked lower rates MBS tranches into new securities, and "squared or "cubed" versions of the latter) to ostensibly reduce the risks to lenders posed by mortgage defaults (Engel & McCoy, 2011: 52). This "securitization machine" had the effect of massively expanding extensions of credit – spinning "endless amounts of Wall Street gold…out of even the most suspect and speculative straw" – to American consumers for propping up global demand, providing apparently low risk and high reward assets for investors from all over the world, and supercharging interbank lending markets that enabled banks to engage in highly leveraged speculative investments (ibid: 54). A combination of consistently rising oil prices and rate increases on adjustable rate subprime mortgages catalyzed a wave of defaults across the US housing market between 2005 and 2007 – an event that financial risk models believed to be virtually impossible (ibid). As Adam Tooze writes, "never before, not even in the 1930s, had such a large and interconnected system come so close

it is fair to say, as John Smith argues, that "systemic crisis affecting all imperialist nations is by definition a world crisis" (J Smith, 2016: 301).

to total implosion", a view echoed throughout the upper echelons of US economic policy (Tooze, 2018: 9). After the housing bubble burst, close to $10 trillion worth of assets were written off, and a depression was staved off by a massive bailout to the financial sector. Following a few years of coordinated stimulus by leading capitalist economies, the dominant response became a mix of national "austerity" to pay down the massive debts incurred along with "quantitative easing" by central banks to artificially lower interest rates and stimulate the extension of credit to businesses and consumers. However, such policies have had the primary effect of funneling more money into financial speculation, inflating asset prices (especially stocks and bonds), with investments in assets like real estate, stocks, and bonds being deemed safer and more rewarding than investing in production (Pettifor, 2017; Standing, 2017). Inequality has only increased, with the top 1% capturing 95% of the gains from economic growth since 2009 (Tooze, 2018: 453), twenty six billionaires now hold the same wealth as the poorest 3.8 billion people (Elliot, 2019), and the "systemically important" (i.e. "too big too fail") banks primarily responsible for the 2008 crisis have only grown larger – expanding by 37% between 2008 and 2013 (Tooze, 2018: 316).

While many simply blame the 2007-08 financial crisis on excessive financial deregulation driven by the ideology of market efficiency, this begs the question, as Martin Wolf and others contend, of "why such policies were adopted" in the first place (Wolf, 2014: 173)? Here we see a remarkable degree of convergence between mainstream Neo-Keynesians like Wolf and Larry Summers, on one hand, and Marxist analysts on the other, who agree that financial deregulation and easy credit "were the way to sustain demand in an economy suffering from demand-deficiency syndrome" (Wolf, 2014: 173; see also Harvey, 2010: 118; Summers, 2016). In this sense, the GFC can be understood as a spectacular symptom of a deeper malaise in global capitalism, in which to "achieve no more than a 'normal' rate of growth" it must "[rely] on 'abnormal' financial bubbles" (Tooze, 2018: 453), thereby setting itself up for successive rounds of mediocre debt-fuelled growth punctured by financial crises.

Mediocre growth, even stagnation, has in this way become the "new normal" for the global economy, seen in declining rates of GDP growth, labor productivity, per capita income, and investment (though these trends are geographically uneven, with the worst impacts felt in the rich world and particularly the Eurozone) along with continuing high rates of under-employment[24] (Gordon, 2016). And alarmingly, many economists across the spectrum agree that the underlying structural causes of the 2008 crisis – from global imbalances to intensifying inequality, weak consumer demand, credit-fueled consumption, and systemic risk in the financial system – remain unresolved and leave us poised for another major crisis (Wolf, 2014; Keen, 2016). Steve Keen warns that many of the "richest" economies (including the U.S., U.K., and many other European economies) remain "debt zombies" where private debt exceeds 150% of GDP and credit has exceeded 10% for at least five years (Keen, 2016: 88). Meanwhile, many other countries – most notably China – are continuing to stimulate growth via debt, though debt is rising much faster than nominal GDP (ibid: 94-95).[25] Total public and private debt levels

[24] A Princeton study concluded that 94% of the nine million new jobs created since 2006 were temporary or contract based (Katz & Krueger, 2016). And a broader survey of economic data paints a strikingly dire picture for the US economy as a whole. In 2017 about 30% of American families struggled to pay food, healthcare, housing or utility bills; about 80% of Americans are reportedly living paycheck to paycheck; most people in this group are unable to afford emergency spending; and household debt has reached all-time highs ($13.2 trillion in 2018) (Reich, 2018; Buchheit, 2017). In the Eurozone, meanwhile, unemployment stood at 9.1% in 2017, underemployment (including those who gave up looking for a job) at 18%, while youth unemployment (for those between 15 and 24) stood at 19.1% and underemployment at 44% (Stiglitz, 2018: xii).

[25] China's credit to GDP ratio increasing an alarming 30% since 2012 (a rate that has historically been associated with imminent crisis) (Reid et al, 2017; Keen, 2016: 81).

reached 250% of GDP in 2018 – compared to 207% in 2007 before the financial crisis, with the IMF fearing that "market participants appear complacent about the risk of a sharp tightening of financial conditions" (IMF, 2018: ix). Meanwhile, financial reforms adopted in the wake of the financial crisis are being weakened by the Trump administration in the US, which will likely intensify financial risk-taking and exacerbate overall financial systemic risk (Tooze, 2018: 588). The global economy also faces further pressure from central bank "tapering" in bond and other asset purchase, which is intended to return interest rates to historically normal rates (primarily to reduce the threat of inflation and create room for maneuver in the case of another crisis) (ibid: 606). Many therefore fear that rising interest rates may catalyze a wave of debt defaults among over-indebted consumers and businesses, while also triggering capital flight from emerging markets with heavily dollar-denominated debts, which was hinted at by the 2014 "taper tantrum" (ibid: 478). The US Federal Reserve has slowed its tapering and reduced interest rates in response to fears generated by the US-China trade war, which means that, as the IMF warns, central banks "may have little left when the economy is in a tougher spot" (IMF, 2019: xiv). A financial assessment from Deutsche Bank economists articulates the problem in more alarmist terms:

> Could the next recession be the one where policy makers are the most impotent they've been for 45 years or will they simply go for even more extreme tactics and resort to full on monetisation to pay for a fiscal splurge? It does feel that we're at a crossroads and the next downturn could be marked by extreme events given the policy cul-de-sac we seem to be nearing the end of (Reid et al, 2018: 33).

Such questions will likely be answered over the next two years as governments respond to the Covid-19 pandemic and its economic fallout. Indeed, the shock has arrived, and Central Banks are using all the (limited) firepower at their disposal to keep markets afloat. A massive wave of debt defaults among businesses and consumers, who were already on the edge of their ability to service their debts, is likely, with yet-to-be-determined implications for financial markets (Smith, 2020), though it is too soon to tell whether (and how) governments may stave off the worst.

In sum, the above trends make clear that the global economy remains in an incredibly precarious position. Yet many continue to believe that, as James Galbraith says regarding Neo-Keynesian economists, that

> the problem is simple, the solution known, and the missing ingredients are only economic understanding and political will. The problem is a shortage of effective aggregate demand. The cure is more spending by government, business, foreigners, and private households (Galbraith, 2014: 238).

In other words, if we could only get beyond the ideology of austerity, neoliberal faith in self-correcting markets, and the obstructive power of the financial industry in order to pass an ambitious and comprehensive Keynesian stimulus, such economists believe that the global economy would readily return to its historic growth trajectory[26] (e.g. Krugman, 2013; Stiglitz, 2016; Summers, 2016; Palley, 2012; Keen, 2016). However, there are at least two major reasons why this is unlikely. First, as Galbraith and others show (and as I'll elaborate more below), Keynesian policies in the past were able to succeed largely because of the existence of abundant cheap energy, though the trends toward global "net energy decline" and increasing energy market turbulence suggest that such conditions are a thing of the past (Galbraith, 2014: 239; Ahmed, 2017; Murphy & Hall, 2011). Second, as documented in the previous section, the earth system crisis is intensifying, and we should be skeptical of claims that a Keynesian fuelled growth trajectory would be

[26] Thomas Palley gives a classic articulation of this position: "The underlying problem is the neoliberal paradigm that has ruled policy making for the past three decades. The challenge is to replace that paradigm with a structural Keynesian paradigm that rebuilds a stable income- and demand-generating process that restores shared prosperity…If policy makers get policy right, it will be possible to construct a prosperous future" (Palley, 2012: 125).

compatible with efforts to stabilize the climate and prevent ecological collapse. This problem must be investigated in greater detail.

Global Capitalism and the "Decoupling" Challenge

On one hand, many believe that there is no contradiction between continuous GDP growth and climate stabilization. For example, Nicholas Stern claims that mitigating climate change will only limit growth by 1-3% per year by 2050, the IEA believes that transitioning to a renewable economy can actually *increase* growth or at least continue historic trends, and all of the IPCC's "Shared Socioeconomic Pathways" assume indefinite 2-3% annual compound growth (Stern, 2006; IEA, 2017; Kuhnhenn, 2018). According to these optimistic visions, the need for growth and ecological regeneration need not constitute an absolute contradiction but can be reconciled by "decoupling" growth from environmental impact by improving energy efficiency, taxing carbon and other forms of pollution, and developing "green" technologies from solar energy and biofuels to closed loop production methods (Hawken et al, 1999; Blomqvist et al, 2015; Asafu-Adaye et al, 2015; Rockström, & Klum, 2015). The problem, however, as numerous studies from ecological economists have demonstrated, is that "decoupling" growth from environmental impact is limited at best, and a dangerous illusion at worst (Kallis & Hickel, 2019; Parrique et al, 2019; Ward et al, 2016; Wiedmann et al, 2015).[27]

For one, while recent trends show that economic growth is slowly decoupling from CO2 emissions (Figueres, 2017; IEA, 2016), this ignores rising emissions from

[27] In the jargon of environmental economists, *relative* decoupling in which emissions and material-energetic intensity per unit of GDP decreases is possible, but there is to this point no evidence that *absolute* decoupling is possible, which would involve a complete break between GDP growth and growth in material-energetic throughput (Asafu-Adaye et al, 2015).

methane as natural gas replaces coal plants (due primarily to leakage from shale gas wells and delivery pipelines), which many scientists believe to be a primary (if not the main) driver of rapidly rising methane emissions since 2007 (Howarth, 2019; Nisbet et al, 2019). Thus what appears to be a decoupling of growth from emissions may be more accurately seen as a case of *substituting* CO_2 emissions with methane (an even more potent greenhouse gas) (Ward et al, 2016), and the jury is out on whether this has had a net negative, positive, or neutral impact on the climate (Sovacool et al, 2016: 109; McKibben, 2018).

More importantly, optimistic claims about the compatibility of economic growth and climate stabilization downplay the *problem of speed*, or whether decoupling from carbon emissions can happen fast enough in a context of compound growth to meet the IPCC targets. The IPCC claims that emissions need to peak in 2020 and thereafter fall at a rate of 7-8% annually, reaching net zero by 2050, to provide a 50% chance of meeting the 1.5°C target, whereas they need to fall 3-4% annually, reaching net zero by 2075, to meet the 2°C target (IPCC, 2018: 15). However, there is a bulk of modeling evidence suggesting that the 7% emissions reductions rate is incompatible with compound economic growth. For example, the C-ROADS model developed at MIT projects that the fastest possible rate of decarbonization in a context of compound growth is likely around 4% per year, which would require "the most aggressive possible abatement policies, high subsidies for renewables and nuclear power, plus high taxes on oil, gas and coal" (Hickel, 2019: 55). Other approaches, including Nicholas Stern's influential Review of the Economics of Climate Change, similarly conclude that 3-4% annual reductions would be the fastest rates compatible with economic growth (Anderson & Bows, 2011: 40). While this would be far from capable of meeting the 1.5°C target, such rates may be capable of meeting the 2°C target according to IPCC projections, assuming that an ambitious globally coordinated mitigation program begins in the year 2020 (or very shortly thereafter). However, given the likely conservatism of IPCC targets, which do not consider positive feedbacks in the earth system (Steffen et al, 2018), there is good reason to be skeptical that 3-4% annual decarbonization would be sufficient to meet even the 2°C target. Other approaches accounting for these feedbacks argue that 7% reductions per year, reaching net zero emissions by 2050, would give us a 66% chance of stabilizing temperature increases at 2°C (Rockström et al, 2017).

In short, the problem is that so long as the economy continues to grow, the mountain of energy consumption that carbon-free energy must conquer only gets higher, requiring even faster rates of decarbonization.[28] As Jason Hickel explains:

> If we assume that global GDP continues to grow at 3% per year (the average from 2010-2014), then decarbonization must occur at a rate of 10.5% per year for 1.5°C, or 7.3% per year for 2°C. If GDP slows down and grows at only 2.1% per year…then decarbonization must occur at 9.6% per year for 1.5°C, or 6.4% per year for 2°C. All of these targets are significantly beyond what existing empirical models indicate is feasible (Hickel, 2019: 55).

Climate scientist Kevin Anderson starkly summarizes the implications of these findings (in a manner atypical for a scientist):

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[28] Optimists might counter that this conclusion assumes that energy consumption must increase along with economic growth, whereas certain trends suggest that the later is *relatively* decoupling from energy and can eventually reach a state of "absolute decoupling" where economic growth increases even as energy use plateaus or declines (Asadu-Adaye et al, 2015). It is indeed true that energy consumption is plateauing in the US and many European countries even as their economies grow, while the "energy intensity" of the global economy has continued to decline (though at a slower rate in the past year) – signifying a trend towards relative decoupling between global economic growth and energy use (Enerdata, 2019). However, again the question is whether energy intensity can be improved fast enough, and whether the *global economy as a whole* (rather than individual countries able to offshore their emissions) can absolutely decouple from rising energy consumption (Ward et al, 2016). Hickel and Kallis show that there is only one empirical model (Grubler et al, 2018) that feasibly accomplishes the emissions reductions compatible with the Paris agreement without relying on negative emissions technologies, which does so by reducing global energy demand 40% by 2050 (Hickel & Kallis, 2019: 12). This would be utterly unprecedented: it is one thing to reduce the energy intensity of the global economy (i.e. for energy consumption to grow more slowly than total GDP) and quite another to *shrink* total energy consumption even as the global economy expands, and the Grubler et al study offers no evidence that this is feasible in practice (ibid).

> In the 1990s, [incrementalist] approaches could have reduced emissions in line with a 2 °C global-warming target. However, climate change is a problem of cumulative emissions. Ongoing failure to mitigate emissions has pushed the challenge from a moderate change in the economic system to a *revolutionary overhaul of the system*. This is not an ideological position; it emerges directly from a scientific and mathematical interpretation of the Paris climate agreement (Anderson & Jewell, 2019; emphasis added).

Therefore, optimists who ardently believe in the compatibility of climate stabilization and economic growth *must* rely on a massive rollout of "Negative Emissions Technologies" (NETs) later this century – from direct air capture to power generation with carbon capture and sequestration (CCS) to Bioenergy with CSS (BECCS). Indeed, all of the IPCC's "Representative Concentration Pathways" compatible with 1.5 or 2 °C rely on a significant rollout of NETs (IPCC, 2018). However, the problem is not only that these technologies are presently hypothetical and unproven at scale, but also that they would entail massive land, energy, and water requirements for building the necessary global infrastructure to put a dent in global emissions (i.e. removing 5 gigatons or more of carbon per year by 2050 and up to 20 annually by 2100). For example, the IPCC's fifth assessment report estimates that the scale of BECCS plants needed would "require plantations covering land two to three times the size of India, which raises questions about land availability, competition with food production, carbon neutrality, and biodiversity loss" (ibid: 10). And the scale of CCS plant construction would rival the size of the current global energy infrastructure, as Vaclav Smil explains:

> in order to sequester just a fifth of current CO2 emissions we would have to create an entirely new worldwide absorption-gathering compression-transportation- storage industry whose annual throughput would have to be about 70 percent larger than the annual volume now handled by the global crude oil industry, whose immense infrastructure of wells, pipelines, compressor stations and storage took generations to build (quoted in Skuce, 2016).

Such schemes might be possible through a massive globally coordinated effort, and technological innovation is to be expected. But those who confidently expect NETs to eventually make climate stabilization compatible with economic growth, simply put, are "taking a very large risk with our common future" (Antal & Van den Bergh, 2016: 171).

Furthermore, in addition to decoupling from carbon emissions (which is arguably the relatively "easy" challenge), economic growth must also be *absolutely* decoupled from impacts on other planetary boundaries that may have already been overshot, which include land use change, biodiversity loss, and nitrogen/phosphorous loading (Raworth, 2017). A number of ecological economists believe that to bring humanity back into a "safe operating space", total resource consumption should be reduced to 50 gigatons per year (from 70 gigatons in 2013) (Hoekstra & Wiedmann, 2014), while a "Half earth strategy" that protects half of total land should be implemented to reverse the tide of mass extinction (possibly by 2050 to ward of irreversible tipping points) (Willett et al, 2019; Kallis & Hickel, 2019). Even if these claims are exaggerated, this would mean that total resource consumption and land use needs to shrink, remain stable, or only increase moderately (depending on our assumptions regarding the further stress (if any) that planetary boundaries can handle) even as the total output of the global economy *triples* by 2060. It is thus not hyperbole to say, as Boris Frankel puts it, that this goal of absolute decoupling is "overwhelmingly staggering in its ambition and historical novelty" (Frankel, 2018: 127).

In sum, we can see that global capitalism faces a precarious situation of unprecedented debt, inequality, and financial systemic risk *before* even expanding our gaze to the broader earth system crisis, while the latter places significant (possibly fatal) constraints on efforts to restore growth in the near and long-term.[29] Even if Keynesians like Paul Krugman, Joseph Stiglitz, and Thomas Palley are correct that a "New Deal" (or "Green New Deal") style effort can create a more prosperous and equitable global capitalism, they have so far been unable to persuasively demonstrate that such efforts are compatible with climate stabilization. Furthermore, as noted previously, they may ignore the extent to which a looming energy crisis – summed up by the phrase "net energy decline" – will place *additional* constraints on global capitalist restructuring and the feasibility of continuous compound growth. To this issue we now turn.

The Global Energy Crisis

Energy is the foundation of life and social organization, the ultimate geopolitical prize that confers hegemony or constraint that spells military defeat and/or geopolitical decline (Yergin, 1992). Yet discussion of a "global energy crisis" – in the sense of a crisis of *source* depletion*,* not simply of its sink effects (i.e. climate change) – remains curiously limited in IR and beyond. We may hazard three reasons for this tendency towards ignorance of and/or skepticism towards a looming crisis of energy depletion. First and most obviously would be the "biophysical blindness" that pervades the social sciences and IR in particular, or the neglect of biophysical parameters like energy in the constitution of human societies. Another would be the dominance of neoclassical economics among policy makers and global institutions like the International Energy Agency (IEA), for whom, as Jorg Friedrichs explains, "it is simply axiomatic that, in an

[29] It is worth noting here that I have not even touched on the question of how climate impacts will themselves constrain efforts to restore economic growth by destroying fixed capital, diminishing labor productivity, and funneling capital from productive to unproductive investments (to be explored further in chapter six). This the earth system crisis exacerbates the structural crisis of capitalism both due to the demands of mitigation as well as direct biophysical impacts.

effectively functioning market, supply will always meet demand" (Friedrichs, 2013: 116). Therefore, despite being originally created to provide early warning of potential supply shocks, "no country has seriously urged the IEA to investigate the risk of energy scarcity" (ibid: 115), even though evidence suggests it remains a potent (if uncertain) threat to the global economy and world order in the coming years. Finally, we can attribute dismissals of the threat in part to what we could call the "boy who cried wolf syndrome" – a general attitude of disbelief and skepticism given the premature predictions of "peak oil" in the past. But as the late ecological economist David Fleming reminds us, there are at least two lessons to be learned from the boy who cried wolf fable: on one hand, "avoid giving false alarms", and on the other, "don't be misled by previous false alarms" (since the wolf came in the end) (Fleming, 2016: 8).

The problem of energy depletion is not simply a matter of available sources in nature (e.g. the amount of remaining fossil fuel reserves) but of how rates of depletion and extraction are shaped by geopolitical, economic, and technological processes. A narrow focus on the former underpinned many early analyses of "peak oil" – the view that oil production rates would soon peak and decline shortly thereafter – which believed that, as the availability of easy-to-access oil diminished and production began to plateau, prices would spike and a new era of permanently expensive oil would begin (Heinberg, 2005; Kunstler, 2005).[30] Indeed there are clear biophysical trends that signal the end of abundant cheap energy, including the depletion of existing oil fields, a diminishing rate of oil field discovery (with 2017 setting a record for lowest discovered conventional volumes globally), a steady decline in the global average of "Energy Return on Investment" (EROI), and an apparent plateau in the rate of *conventional* oil production

[30] Though some did indeed anticipate the sort of price swings we've seen (e.g. Greer, 2008: 108-111).

around 75 million barrels per day since 2005 (though total production has increased since 2011 with the rise of shale oil extraction in the US) (Ahmed, 2017; Rubin, 2009; Boyd, 2013; Murphy, 2014).[31] However, such trends have not so far born out early predictions of a permanent price spike. They appeared to materialize between 2006-08 with the energy price spikes that contributed to the great recession, which occurred through a combination of plateauing conventional oil production and surging demand from China and India (Thompson, 2017). However, as many economists predicted, rising prices made exploration and development of unconventional fields more profitable, which fortuitously converged with historically cheap credit (due to quantitative easing) and technological breakthroughs in hydraulic fracturing to create a new wave of oil abundance and low prices (ibid). For many this appeared to lay the peak oil narrative to rest, or at least indicated that it was a much less serious near-term problem than many of its proponents believed. For example, noted energy analyst Daniel Yergin argues that we are likely witnessing the early phases of a global production plateau rather than a peak, in which higher prices will continuously incentivize exploration and discovery of unconventional oil reserves for at least several decades (Yergin, 2011: 227-228; see also Jackson & Smith, 2014). This view is shared by critical political ecologists like Gavin Bridge and

[31] Additionally, many commentators believe that "proven" oil reserves have been inflated by state and corporate oil majors. For example, Michael Jefferson, former chief economist at Royal Dutch Shell Group, reports that "the five major Middle East oil exporters altered the basis of their definition of 'proved' conventional oil reserves from a 90 percent probability down to a 50 percent probability from 1984. The result has been an apparent (but not real) increase in their 'proved' conventional oil reserves of some 435 billion barrels." He thus concludes that "the standard claim that the world has proved conventional oil reserves of nearly 1.7 trillion barrels is overstated by about 875 billion barrels" (quoted in Ahmed, 2017: 19). A similar tendency appears to be the case in the US shale oil and gas industry, where former Merill Lynch consultant Deborah Rogers reports that reserves were overestimated by at least 100% and perhaps as much as 400% in order to drive a Wall-street credit-fueled bonanza (Rogers, 2013). While many believe that oil and gas firms actually understate their proven reserves to put upward pressure on prices, in an age of dwindling supplies they are actually incentivized to inflate their stated assets since this gives them easier access to credit needed to explore and develop unconventional fields (Di Muzio, 2016: 35).

Philipe Le Billon, who argue that "liquid hydrocarbon production looks set to 'plateau' rather than peak and rapidly decline" (Bridge & Le Billon, 2017: 233).

Following these assumptions, many therefore believe that peak oil narratives merely distract from the real problem – climate change and our collective squandering of the remaining "carbon budget" before catalyzing catastrophic tipping points in the earth system (Bridge, 2010; Klare, 2015). Indeed, there is clearly enough accessible oil and gas to blow up the climate system, especially due to recent advances in hydraulic fracturing, deep sea drilling, and the increasing availability of arctic oil (Klare, 2015). However, these analysts often ignore at least two crucial dimensions of the energy problem that increase the risk of near-term scarcity. The first is that they tend to downplay the importance of *net energy,* or "Energy Return on Investment" (EROI), which scholars like Charles Hall, David Murphy, and Nafeez Ahmed argue should be the primary gauge of supply risk (rather than total reserves). EROI refers to the energy used to obtain a given quantity of energy, which includes the energy *directly* used in the extraction process as well as the energy used *indirectly* in various stages of its lifecycle (e.g. the energy used to manufacture and maintain a power plant or oil rig, or to deliver the energy to its point of use) (Murphy, 2014: 2). As David Murphy estimates, the average EROI for US oil production has declined from about 20 in the early 1970s to 11 today, while the global average was roughly 30 in 2000 and has declined to roughly 17 today, whereas the EROI from deep-water drilling is probably lower than 10 and lower than 5 for shale (ibid). When easy to access oil with a higher EROI is depleted, unconventional reserves with a lower EROI leave less energy available for the rest of the economy, which places biophysical limits on its ability to expand (Ahmed, 2017; Murphy, 2014). Therefore, rising production rates in the short-term (as in the US shale oil and gas industry) are not necessarily signs of overall health, since more and more energy is simply being channeled into the extraction, processing, and distribution of unconventional oil and gas, while *net* energy levels available to the rest of the economy decline (Ahmed, 2017: 21-22; Murphy & Hall, 2011). Though calculations of EROI are subject to uncertainty, a striking correlation exists between estimated declines in fossil fuel EROI and the long-term decline in global GDP growth rates, suggesting that the former is likely a key contributing factor to “secular stagnation” and the increasing reliance of capital accumulation on debt (Ahmed, 2017: 27; Jackson, 2018).

Second, peak oil skeptics may downplay the ways in which feedbacks between energy depletion and economic stagnation create a more destabilizing crisis architecture than by looking at the former in isolation (Korowicz, 2011; Boyd, 2013). In sum, optimistic forecasts predicting energy abundance for decades, and even moderate voices anticipating a long-term plateau, may ignore the way that economic stagnation reduces demand and can therefore push prices below what would be profitable to develop unconventional reserves, therefore leading to supply shocks. This creates what James Galbraith calls a “choke chain effect” in which stagnant growth pushes down energy prices, which then slows down the rate of exploration and development of new fields; subsequently, if and when economic growth begins to recover, energy prices rise while limited exploration leads to a supply shortfall that raises prices beyond a level that can sustain economic growth, thus “choking” off the recovery (Galbraith, 2014: 239). In this way we may experience what Jeff Rubin calls a “damaging cycle of recessions and recoveries that keep repeating itself as the economy keeps banging its head on oil prices”

(Rubin, 2009: 23). Energy analyst David Murphy frames this predicament in terms of the increasingly "narrow ledge" of oil prices, or the range in which oil prices are profitable for producers but not so high as to hinder economic growth (Murphy, 2014: 6). As he explains:

> developing new unconventional oil production in Canada (i.e. tar sands) requires an oil price between $70 and $90 per barrel…the average oil price during periods of economic growth over the past 40 years was under $40 per barrel, and the average price during economic recessions was under $60 per barrel…What these data indicate is that the floor price at which we could increase oil production in the short term would require, at a minimum, prices that are correlated historically with economic recessions (ibid).

The effects of this increasingly "narrow ledge" can be seen in bankruptcies across the US shale oil and gas industry due to consistently low prices that fail to make up for capital-intensive investments, record low quarterly profits for oil giants like Exxon Mobil and Royal Dutch Shell since 1999 and 2005, and IEA warnings of insufficient investment in new fields to make up for production declines in existing fields (Whipple & Andrews, 2018). It is possible that the choke chain dynamic will play out as a repetitive seesaw between moderately high (e.g. $70-80 per barrel) and moderately low (e.g. $50-60 per barrel) oil prices – thus reinforcing economic stagnation but without delivering a critical supply shock to the global economy. However, we should also recognize the possibility that insufficient investment in developing new fields (due to low prices), combined with constraints on ramping up unconventional production when prices increase (e.g. due to geological depletion of the "sweet spots", water scarcity, geopolitical instability, and constricted credit flows), will generate crippling supply shocks with irreversible consequences for the global economy,[32] which will become more likely as the global

[32] For example, David Hughes shows that optimistic forecasts about rising production from shale oil and gas assume that all technically recoverable reserves can be extracted at the same rate and cost as the "sweet spots" that are already

economy increasingly relies on unconventional reserves (especially by 2030, according to some projections of declining conventional production in Saudi Arabia[33]) (Ahmed, 2017: 72-73).

While it is therefore certain that global capitalism will be confronting a prolonged era of price volatility in energy markets, much uncertainty remains concerning if and when a major supply shock will materialize. The Covid-19 pandemic has demolished oil demand by nearly a third across the world economy, with benchmark crude prices temporarily entering negative territory and hovering around $24 per barrel as of the present writing, which may appear to lay the fear of near-term supply shocks to rest. However, as numerous commentators emphasize, the choke chain dynamic is likely to go into effect in the coming years as dramatic reductions in exploration and development of new fields, combined with resurgent demand when the economy recovers, pave the way for “an era of long-lasting oil scarcity from which there may be no recovery” (Ahmed, 2020b; see also Chapman, 2020). This scenario may be avoided if the world economy enters a protracted downturn or if the current shocks catalyze a rapid build-up of non-carbon alternatives, in which case narratives of “peak demand” may win the day (Raval et al, 2020). In any case the pandemic has accelerated the ongoing shake-up in energy markets and the global energy system, and only time will tell how the crisis will unfold in coming years.

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in decline (Hughes, 2018). Furthermore, 53% of shale wells in the Permian basin – the primary source of anticipated growth in shale production – are located in areas with high water risk, which will worsen with climate change (Cunningham, 2019). Therefore, while we should not discount the potential for further technological innovation to bring new unconventional sources online in response to future price shocks, we should at the very least question the view that markets will always succeed in restoring sufficient supply.

[33] As Nafeez Ahmed reports, a recent study commissioned by the geological survey of Finland concludes that Saudi Arabia is likely approaching (and may have already) passed) a production peak: “The study cites accelerating rig counts amid disproportionately low oil output as mounting evidence of the Saudi oil sector’s declining productivity. It also cites data from the recent IPO held by the Saudi national oil firm, Aramco, indicating that production levels from the country’s largest field, Ghawar, is 1.2 million barrels lower than previously claimed, suggesting the field is nearing maturity” (Ahmed, 2020a; see also Michaux, 2019).

Renewable Energy to the Rescue?

Many optimists are predicting a near-term peak in oil demand and end of the fossil fuel era due to the forces of political-economic and technological change driving the transition to renewable energy (Helm, 2016). Indeed the costs of renewable energy and battery storage systems are steadily falling (even out-competing coal in some localities), technology continues to improve, and political and financial forces rallying around the Paris agreement are pushing to "shift the trillions" from investment in fossil energy to renewables (IEA, 2017). Thus for these analysts, accelerating the renewable energy transition through a standard mix of tax and subsidy policies will be sufficient to simultaneously resolve the entwined crises of climate, energy, and capitalism. Indeed, given the limited carbon space available before triggering catastrophic climate change, the future of global capitalism is itself dependent on whether renewable energy can rapidly become a sufficient source of cheap energy (perhaps in conjunction with nuclear energy) to power a continuous growth trajectory. While there is much uncertainty, a sober analysis encourages skepticism (or at best agnosticism).

It can be challenging for a non-expert to assess the future potential of renewable energy based on the current literature, which is often divided between techno-optimists on one side promising an era of limitless renewable energy (e.g. Diamandis & Kotler, 2014), and pessimists on the other side emphasizing the (possibly insurmountable) technical hurdles it confronts (Trainer, 2010; Clack et al, 2016; Heard et al, 2017; Moriarty & Honnery, 2012). However, a middle range position appears to be the most plausible: while a complex industrial society powered by 100% renewable energy (involving a geographically diverse mix of solar, wind, geothermal, hydropower, biofuels, and hydrogen) seems entirely plausible, it is unlikely that a global capitalist economy based on *endless compound growth* could be powered entirely by renewables (Heinberg & Fridley, 2016; Capellan-Perez et al, 2019; Diesendorf & Elliston, 2018; Di Muzio, 2015). For one, while optimists often point out that an area the size of the Sahara desert (2 million square meters) could provide 50 terrawats of solar energy (more than double current global energy use) (Diamandis & Kotler, 2014), this ignores the difficulties and costs associated with converting this latent energy into usable form. This is primarily due to the challenges of intermittency, land-use (as well as water) demands (due to need for larger geographic footprint than with fossil fuels), and the limited EROI of renewables once full life-cycle costs of mining, transporting, and constructing smart energy grids and battery systems are taken into account (Smil, 2010: 116-117; Heinberg & Fridley, 2016: 7-9). While various studies come to different conclusions for different geographic sites, the EROI for a renewable energy system overall (rather than individual solar and wind farms), is likely to be between 5 and 20 (Murphy, 2014; Heinberg & Fridley, 2016: 117-119). While significantly lower than the EROI of fossil fuels that powered capitalist globalization, the upper end of this range would certainly be sufficient to power a complex steady-state civilization, though perhaps not indefinite 2-3% compound expansion (since a higher proportion of produced energy would need to be reinvested in further energy production) (Heinberg & Fridley, 2016: 119). Optimistic analysts believe that the EROI of renewables will only increase over time as technological innovation improves efficiencies (e.g. Schwartzman & Schwartzman, 2018).[34] However, others contend that this ratio is likely to fall rather than increase over

[34] While some believe that renewables will follow a Moore's law-like technological expansion, Vaclav Smil argues that such an explosion is unique to the technology of microprocessors and cannot be replicated by solar energy and

time: first, due to the need for large-scale storage, which itself imposes high energy costs (Heinberg & Fridley, 2016: 118-119); second, due to the progressive exploitation of higher-quality renewable energy sources, thereby requiring shifting to lower quality locations with less return on investment solar and wind energy from more intermittent locations (Honnery & Moriarty, 2012); and third, due to the need to build new energy grids and increase energy-intensive extractivism to provide the minerals for the transition (Capellan-Perez et al, 2019).[35] Thus while there is no way to definitively forecast how much total energy will be available in a renewably-powered future, there are good reasons to support the view that energy quantities will need to be significantly lower than business as usual global energy demand projections from agencies like the IEA (Heinberg & Fridley, 2016). Even renewable energy optimists like Mark Jacobsen believe that a fully renewable powered global economy will require a 57% reduction in energy demand, which would be feasible in a steady-state economy but not in one reliant on endless compound growth (given the constraints on decoupling described earlier) (Jacobsen et al, 2019; see also Diesendorf & Elliston, 2018: 324)

There is also the problem of whether a combination of renewables and biofuels could successfully replace the current oil-dependent transportation infrastructure on which the global economy fundamentally depends. To put this in perspective, shipping

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photovoltaics (Smil, 2010: 119). Heinberg and Fridley also note that there are likely physical limits to battery improvements and solar panel efficiency. While we should not discount unexpected technological breakthroughs, as I discuss below, these limits suggest that we should be skeptical at best of the cornucopian position.

[35] Current projections are that the global production of key metals and rare earth minerals – including lithium, neodymium, terbium, and indium – would need to grow by at least a factor of 3 or 4.5, and possibly up to 12, to meet the material needs of a fully renewable energy grid, battery systems, and electric vehicles (De Koning et al, 2018; Ahmed, 2018). This not only raises the specter of mineral scarcities and geopolitical conflict, since 80% of raw material mining and 95% of refining is currently concentrated in China, but would also "intensify the current socio-environmental conflicts related with the expansion of the extraction frontier globally" (Cappellan-Perez, 2019: 17). Current rates of metal recycling are below 1%, and thus higher rates of recycling could significantly reduce rates of extraction and the risk of shortages associated with a renewable energy build-up (Ahmed, 2018). Yet "a cost-effective PV-waste collection and recovery system capable of high-value material recovery remains elusive" (Mulvaney, 2019), and it may require energy-intensive recovery processes that would further reduce the EROI of a renewable energy system (Capellan-Perez et al, 2019).

consumes 7.4% of oil annually but accounts for 90% of global trade, and this entire infrastructure, as well as our way of life built around it, was enabled by the existence of cheap fossil fuels with a high EROI. Could these high levels be maintained with sails, electrification, or fuel substitution? Alice Friedmann, among others, says no: that we are in fact facing a "a transportation fuel crisis", since "biofuels, batteries, and electricity from windmills, solar, geothermal, and nuclear power plants won't keep trucks, tractors, locomotives, and ships running" (Friedemann, 2016: 123). There are of course many efforts to innovate our way through this crisis, but all of them face major challenges. Biofuels, for one, are notoriously expensive in energy, water, and land-use demands, and their augmentation was in part responsible for the food price spikes in 2008, so these likely cannot be scaled up without humanitarian costs (Rulli et al, 2016).[36] While electrifying shipping may be possible through new battery-powered ships, there is a big question mark of whether the relatively low EROI of renewables in conjunction with battery technologies would enable shipping to be sustained at its present rate. As Heinberg and Fridley, this is because electrifying transport will put significant extra burden on solar and wind technologies, which may be already over-taxed in their ability to decarbonize electricity (Heinberg & Fridley, 2016: 93). Thus as oil production costs rise and the limits of renewable energy become increasingly clear, they predict that societies will become less mobile, global trade will decline, and the era of "peak globalization" will ensue (ibid; see also Curtis, 2009).

[36] Advances are being made in "next generation biofuels" (e.g. algae), which may create new substitutes without the same problem-shifting effects in the food sector. But it remains questionable if these could deliver a high enough EROI to be scaled up globally, and they may place unsustainable demands on water (Friedemann, 2016: 42). And if they *do* become feasible, this could enhance violence-interdependence by diffusing biotechnological capabilities and infrastructure (as I'll discuss later in this chapter).

The problem further deepens when we take into account the need to use fossil fuels to build a self-sustaining renewable infrastructure. As Jorg Friedrichs reminds us:

> solar cells do not produce solar cells, and wind turbines do not produce wind turbines…non-renewable energy is subsidizing renewable energy…at some point, the production and maintenance of the renewable energy infrastructure will have to be fueled by renewable energy (Friedrichs, 2013: 41).

In short, with supplies of oil constrained by both geological depletion and the carbon budget needed to keep global warming under 2 degrees, there is a growing danger that we will simply not have the fossil fuel energy needed to build a similarly scaled renewable infrastructure, let alone to build one with even *greater* material-energy demands. While there are huge uncertainties involved in such calculations, Schwartzman and Schwartzman estimate that a transition to 100% renewable energy by 2050 would use up roughly 20% of proven reserves of conventional oil and gas (Schwartzman & Schwartzman, 2018: 95; for similar estimates see Sole et al, 2018). If this figure is roughly accurate, it implies that powering a global transition would not only eat up a significant portion of the remaining "carbon budget" (which is estimated to be between a fifth to a third of proven fossil fuel reserves[37]) but would also require global planning to prioritize how we use the planet's remaining fossil fuels (Heinberg & Fridley, 2016: 192-193). Ugo Bardi comes to a more dramatic conclusion, claiming that "we need to increase by about a factor of 50 the amount of energy invested in creating a [renewable] energy infrastructure, and do it now" for the transition to be viable (Bardi, 2017: 163). Even if

[37] Bill McKibben, in his often cited article for Rolling Stone, estimates that we must keep a fifth of all remaining fossil fuel reserves in the ground to give us an 80% probability of remaining below 2 C. However, such estimates are based on assumptions regarding the state of climate science, acceptable risk, proven fossil fuel reserves (which can be over or under estimated), as well as assumptions regarding impact of other greenhouse gases like methane and nitrous oxide. Others provide larger estimates of the remaining carbon budget (e.g. Mcglade et al, 2018), while some like Spratt and Dunlop go so far as concluding that "we have no carbon budget for 2°C for a sensible risk-management, low-risk probability (of a 10%, or one-in-ten chance) of exceeding that target" (Spratt & Dunlop, 2017: 15-16). Therefore, carbon budgets they should merely be taken as useful baselines to bring perspective to the current predicament, rather than hard limits (see Clark, 2015).

exaggerated, the implications are clear: global planning will be needed to ration the remaining fossil fuel budget and channel them towards prioritized needs – which include manufacturing and transporting solar panels and wind turbines, sustaining global agricultural production (which may be difficult to rapidly decarbonize[38]), and overcoming energy poverty in the global south (Heinberg & Fridley, 2016: 193). Otherwise, the risk is that market forces would squander them in wasteful forms of energy consumption that leave us with "the worst of all possible outcomes – climate chaos, a gutted economy, and no resources to catalyze a transition" (ibid).

Finally, it is worth briefly considering the prospects of nuclear energy, since many believe it can make up for the intermittency and potentially low EROI of renewables (Brand, 2010; Lovelock, 2010; Hansen et al, 2015). Scaling up nuclear energy could potentially sustain economic growth while decarbonizing economies, though the technical and political-economic (let alone environmental and security) challenges may exceed its potential benefits. For one, nuclear power requires high upfront costs and is not economically competitive without significant subsidies while also being highly prone to cost overruns and high risk of default on loans, which diminishes its attractiveness in an era of economic instability and uncertainty (Sovacool et al, 2016: 256). For these reasons, nuclear energy has actually been on the decline in recent years, with start-ups being outnumbered by permanent shutdowns (Green, 2018). Uranium is also a non-renewable

[38] As Jason Bradford explains: "although you could theoretically run farms with electric-powered equipment, no technology known or likely to become available has the combination of transportability, storability, and high energy density that hydrocarbon liquid fuels offers… Hydrocarbon liquid fuels are the only known substances with enough energy density that can be carried easily onboard a tractor under typical working conditions (e.g., a wide range of temperature; shaking and bouncing on rough terrain) and enable work to be performed continuously for many hours" (Bradford, 2019: 11-12). Of course, the Cuban agro-ecology transition in the 1990s shows that rapid transitions beyond fossil fueled agriculture are possible, though the question is whether this is feasible on a *global-scale* (rather than in a single small country like Cuba, where the combination of socialist governance, tight-knit communities, and the widespread persistence of agro-ecological knowledge made it more possible (Friedrichs, 2013: 92-94).

resource that is expected to peak around 2040 and 2050. While “fast breeder reactors” that recycle used uranium may be able to compensate for shortages as uranium prices rise (Heinberg & Fridley, 2016: 132), they would also create large inventories of spent nuclear fuel containing plutonium, thereby exacerbating nuclear proliferation risks (Avrorin & Chebeskov, 2015). Nuclear advocates also point to the advantages of “Generation IV” reactors on the horizon, which could in theory by built more rapidly and at lower cost, though they are “still far from commercialization” may be deployed on a large scale “no sooner than 2040” (Sovacool & Valentine, 2012: 31). It therefore seems unlikely that nuclear energy will be able to take up a significantly greater proportion of global electricity demand in the future (perhaps at most increasing from 15% to 18%, as the IPCC projects) (Sovacool et al, 2016).

The Global Food Crisis

It is impossible to discuss the global food crisis without touching on all the other dimensions above, since food systems cannot be disentangled from wider political-economic, climate, biodiversity, energy, and transportation systems. It can be said that “crisis” (at least in one sense of the term) is simply a *normal* condition of the global food system, given that between 820 million and 2.5 billion suffer from undernourishment (depending on whether we use the FAO’s more conservative or other measurements) (FAO, 2019; Hickel, 2016); another 2 billion more people suffer from obesity (due to the prevalence of high calorie and low nutrient “junk” food) (Frison et al, 2016); and hundreds of thousands (if not millions) more die annually from unsafe working conditions in farms and slaughterhouses, pesticide poisoning, and noncommunicable diseases (e.g. cancer & cardiovascular disease) caused or exacerbated by obesity (Rocha et al, 2017). Yet as changes in temperature, drought, aquifer depletion, extreme weather, soil erosion, and energy depletion combine with diminishing returns to technological innovation (at least within the dominant agribusiness paradigm) and a growing global population, the currently "normal" condition of food system pathology may be pushed towards further breakdown resulting in unprecedented hunger and social collapse (unless we rapidly change course). It thus seems plausible that, as Lester Brown fears, food may constitute "the weak link in our early twenty-first century civilization" (Brown, 2012: 4).

Rather than focusing merely on of key environmental and demographic trends, as is common in the mainstream food security literature, the global food crisis can only be understood in relation to the history of capitalist agriculture and its transformation under neoliberal globalization in the past few decades. The most recent transformation in the capitalist food regime involved the globalization and monopolization of the farming, processing, packaging, and retail sectors under the auspices of the WTO and enshrined during the Uruguay Round of trade talks. These policies forced many states of the global south to open themselves to more "efficient"[39] producers in the global north, to sell off their emergency grain supplies, and to support new waves of land enclosure that forced peasants off their lands (an estimated 20 to 30 million throughout the global south) to make way for large-scale intensive production (McMichael, 2013: 54). Free trade advocates claimed that producers in the global south would benefit from greater access to northern markets, consumers would pay less due to the efficiencies generated by sharper competition, while those driven off their land would benefit in the end by finding work in

[39] While they are more efficient in the sense of producing more output per *monetary* input, *energetically* speaking they are far less efficient than most traditional methods (producing roughly 1 calorie of food for 10-12 calories of input).

the cities (Murphy, 2010: 105-106). What actually happened was that access to northern markets remained limited and southern states became increasingly dependent on imports from subsidized producers in the global north (ibid: 108). While many southern consumers were treated to lower prices for a time,[40] their dependence on imports made them more vulnerable to the kind of price spikes witnessed in 2007-08 and 2011. Overall, the results have been an increase in the number of food insecure and malnourished people across the globe (from roughly 780 million in 1990 to 1-2.5 billion today), record profits for agribusiness giants, exploitative labor conditions for peasants forced out of the countryside into "export processing zones" (especially in Mexico in the wake of NAFTA), unsustainable influxes of workers into cities throughout the global south creating a "planet of slums" (Davis, 2007), and mass farmer suicides across India[41] and elsewhere (Hickel, 2016; Leech, 2012).

On top of this wave of "accumulation by dispossession" (Harvey, 2003) marshaled through the consolidation of a global agribusiness oligopoly dominated by a vertically integrated network of producers, distributors, and retailers (Howard, 2016; Hauter, 2012), with all its environmental and ethical horrors (e.g. factory farms), we are currently living through the exhaustion of this paradigm's ability to increase agricultural yields. Productive topsoil – the "foundation of civilization" is being steadily eroded much faster than new soil is forming (Brown, 2012: 46); water based "food bubbles" are forming in more than 18 countries, including major global producers like the U.S., China, and India, where steady food production depends on depleting local aquifers (ibid: 60);

[40] Though this was not always the case. Tortilla prices in Mexico actually rose 279% in the wake of NAFTA due to deregulated retail prices on food, while simultaneously impoverishing thousands of Mexican farmers, exacerbating hunger and malnutrition (Hickel, 2017: 206). And even the results in the U.S. have been mixed: Wenonah Hauter reports that most retail food prices actually increased between 2001 and 2010, with only banana and iceberg lettuce prices falling over this period (Hauter, 2012: 92).
[41] Approximately 217,000 between 1997 and 2009 according to the Indian government (Leech, 2012: 56).

grain yields are plateauing while technical efforts to boost it through genetic modification are having minimal effect (ibid: 76); and climate change threatens to reduce yields through a multi-dimensional array of intensifying hazards (discussed further in chapter six).

Furthermore, climate change also intensifies the risk of simultaneous drought and other forms of extreme weather in multiple regions: whereas the impact of extreme weather in one region could traditionally be reduced by normal or abundant food production in other regions, the increased frequency of extreme events across the planet enhances the possibility of multiple regions being affected in the same year (Janetos et al, 2017: 5). Thus these trends are increasing the likelihood of simultaneous crop failures in the major breadbaskets around the world, the impacts of which would be exacerbated by neoliberal trade liberalization policies (Janetos et al, 2017). Whereas earlier food systems were designed for resilience by promoting national self-sufficiency and emergency storage to draw upon in times of stress, today's systems have been designed primarily for efficiency, thereby undermining self-sufficiency, reducing emergency stocks, and intensifying dependence on key breadbaskets (e.g. the US and Canada for Wheat, and India and China for Rice) (Roberts, 2018). In short, they have been "highly optimized for efficiency in peacetime under relatively stable environmental conditions" (Janetos et al, 2017: 5). Anthony Janetos and colleagues explain the implications of these trends:

> as trade continues to increase, breadbaskets become more concentrated, with a possible reduction in resiliency.…[Whereas] more trade and more trading partners leads to increased overall diversification and higher resilience to absorb local production shocks…a system with a large number of trading partners appears more volatile when a systemic risk hits the network (ibid).

Unfortunately, rather than motivating a paradigm shift that emphasizes resilience and agroecological sustainability, dominant framings of the global food crisis continue to advance the same policies, technologies, and ownership structures that have been fueling the crisis in the first place. As Sommerville et al write:

> the food crisis has been widely understood (and represented) as a symptom of a still divided world in need of greater economic integration, as a challenge to extend neoliberal policies in the face of revisionist governments seeking to (re)establish food trade barriers and protect 'their' farmland and agricultural sectors, and as an opportunity to solve long-term food security concerns by closing the 'yield gap' between a 'highly productive' North and an 'under-producing' South (Sommerville et al, 2014: 258).

The discourse of the "yield gap" echoes colonial discourses from the past that justified dispossession of indigenous lands on the grounds of their "limited" productivity (measured according to metrics that ignored their wider ecosystem benefits, energy efficiency, and cultural heritage) (Pretty, 2010). Despite the fact that the agroecological methods practiced by many of these communities are increasingly seen as crucial components of a global strategy to simultaneously resolve the problems of climate change, energy and water depletion, and food insecurity – due to their ability to sequester carbon, improve productivity without fossil fuels or other off-farm inputs, bolster local biodiversity, and diminish water use by building strong soils that retain water and nutrients (not to mention restoring cultural traditions imperiled by capitalist expansion) – continued processes of land-grabbing and agribusiness consolidation continue to marginalize these efforts. Instead, transnational agribusiness corporations, leading states, and international development institutions like the World Bank aim to "green" the current food system through initiatives like "Climate-Smart Agriculture", which primarily involve marginally less resource-intensive versions of the same industrial agricultural model (Holt-Gimenez, 2010; Taylor, 2018).[42] For example, biotechnology firms like Monsanta, Bayer, Syngenta and Dupont are in process of manufacturing "climate ready" seeds with enhanced drought tolerance, though research by the National Academies of Science among others shows that their success has been limited at best and have done more to privatize and patent seeds that had been cultivated by farmers for generations (McMicheal, 2009). The global food crisis must therefore be understood in the context of transnational corporate strategies to secure profitable investments, which are at risk of entrenching a set of global agricultural policies that continue to centralize control of land and seeds; reinforce food insecurity for peasant populations across the global south; deplete soils and biodiversity; squander the carbon-sequestering potential of soil; continue to rely on fossil fuels in the production, processing and distribution of food; and sacrifice cultural diversity to the altar of capitalist "efficiency" (Clapp & Isakson, 2018). Given the evident failures of this model, alongside trends towards net energy decline, earth system destabilization, and a growing population, its continuation will likely result in a catastrophic transition – whether in the form of multi-breadbasket failure and starvation for even greater swathes of under-privileged humanity, political-economic upheaval and widespread transitions to localized agroecological practices, or a combination of the two.

Technology as Savior?

Many will argue that the preceding analysis leaves out the role of technological innovation, which may very well attenuate if not resolve the severity of the coming

[42] For example see Obama's 2014 Global Alliance for Climate-Smart Agriculture, which rests on 3 pillars: increasing productivity, strengthening farmers' resilience, and reducing agricultures GHG emissions, and which excludes small-farmer organizations and social movements (Buxton et al, 2015).

crises. Indeed, technological innovation has always been and continues to be the basis of "doomsday" skepticism (e.g. Kelly, 2012; Lomborg, 2012; Asafu-Adjaye et al, 2015; Diamondis & Kotler, 2014; Pinker, 2018). We should take these arguments seriously, since unanticipated innovations and breakthroughs are undoubtedly to be expected. In particular, many believe in an imminent threshold of exponential technological advance that is sometimes called the "Fourth Industrial Revolution" (FIR) or "NBIC convergence": the convergence of auto-catalytic innovations in biotechnology, nanotechnology, the internet-of-things, Artificial Intelligence (AI), 3d printing, robotics, and other emerging technologies (Schwab, 2017; Ramsden, 2016; Bostrom & Cirkovic, 2011; Blum & Wittes, 2015). Many futurists believe that the FIR will drive a 21st century industrial revolution with political, economic, and social consequences that could match the scale of those felt during the 19th century, and there is a burgeoning literature composed mainly of works by scientists, futurists, journalists, and business consultants trying to grapple with the implications of these developments (Bainbridge, 2007; Drexler, 2013; Nordmann, 2004; Diamondis & Kotler, 2014). As its proponents emphasize, the *convergent* nature of these technologies is what harbors the most potential for catalyzing a 21st century industrial revolution: innovations in computing will amplify and catalyze innovation in biotech, nanotech, robotics, and 3d printing; which would facilitate further innovations in computing and AI; then enabling further nanotech and biotech innovations and applications; and so on in a positive feedback circuit (Schwab, 2017). Klaus Schwab, the founder and executive chairman of the World Economic Forum, effectively captures the hope that many place in these converging technologies:

> A Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized

> by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres…The possibilities of billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to knowledge, are unlimited. And these possibilities will be multiplied by emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing (Schwab, 2016).

Given the immense (arguably insurmountable) challenges of decoupling economic growth from environmental impacts, the limited prospects of current renewable energy technologies, and feeding a growing population in age of climate chaos, it seems likely that to sustain our present growth trajectory *would* require substantial technological breakthroughs and the ability to rapidly diffuse and scale them up. Indeed, this is what many commentators anticipate. Ecomodernist Stewart Brand, for example, affirms that human survival in the 21st century will require both scaling up next generation nuclear reactors to provide the baseload energy needed to balance the intermittency of renewables and power the megacities of the future, as well as intensifying innovation in biotechnology and synthetic biology to creative more resilient crops with higher yields, clean and renewable biofuels, and microbes engineered to cleanse polluted environments and sequester carbon (Brand, 2010; see also Lynas, 2011 for similar arguments). Biologists and biotech advocates George Church and Ed Regis similarly argue that the versatility and potentially unlimited creativity of synthetic biology will be crucial for resolving environmental challenges. In their words:

> Genomic engineering will become more common, less expensive, and more ambitious and radical in the future as we become more adept at reprogramming living organisms, as the cost of the lab machinery drops while its efficiency rises, and as we are motivated to maximize the use of green technologies (Church & Regis, 2012: 7).

Recent breakthroughs in gene-editing and DNA synthesis have enabled new techniques for restoring damaged ecosystems, conserving endangered species, improving biological fixation of carbon, developing bio-based materials, and boosting crop yields by enhancing the efficiency of photosynthesis (Wintle et al, 2017; Maxmen, 2015), thereby raising hopes among environmentalists and governments that the emerging "bioeconomy" can help solve sustainability challenges (Synthetic Biology Leadership Council, 2016).

Others focus on the promise of emerging developments in information technology, particularly AI, big data, and the "Internet of Things" (IOT) – the global network of online devices, sensors, and databases forming a "world-spanning information fabric" (Goodman, 2016: 284). For example, a report commissioned for the 2018 Global Climate Action Summit highlights the importance of these "exponential technologies" for accelerating the transition to a low-carbon economy. It places particular emphasis on the power of the IOT and machine learning to "enable next-generation mobility and electric vehicle breakthroughs, improvements in energy and space efficiency for buildings, and electricity generation and storage" while making cities orders of magnitude more efficient through traffic, energy, and infrastructural optimization (Falk et al, 2018: 80). It also highlights the power of 3d printing to "democratize production" by enabling local communities to print their material and infrastructural needs, thereby making them "far less dependent on global supply chains" (ibid: 33). Overall, the authors believe these technologies can fuel a rapid decarbonization and dematerialization of the economy, with IOT and AI-driven efficiency gains alone enabling 15% emissions reductions by 2030, *without* sacrificing economic growth or rising material standards of living (ibid: 18; see also Messner et al, 2020).

While its technological flowering may not occur for at least another decade or two, nanotechnology is often considered to be the main driving force behind the NBIC3d convergence. For example, inventor and futurist Eric Drexler claims that nanotech

> will increase energy efficiency across a wide range of applications and sometimes by large factors…In ground and air transportation, the accessible improvements include ten-fold reductions in vehicle mass and a doubling of typical engine efficiencies…reductions in the costs of physical capital will lower the cost of new installations of all kinds, facilitating replacement of capital stock at rates that could surpass any in historical experience (Drexler, 2013: 229).

Combined with 3d printing, nanotechnologists claim that "personal nanofactories" will enable any product to be assembled locally, atom by atom, which would bypass energy-intensive supply chains, reduce energy consumption by an order of magnitude (Ramsden, 2016: 288), "essentially eliminate waste" and overcome scarcity by disassembling and reassembling any atomic assemblage into novel material compounds (ibid: 296), and even enabling the rapid creation of a carbon sequestration and storage infrastructure that could "return the Earth's atmosphere to its pre-industrial composition in a decade, and at an affordable cost" (Drexler, 2013: 234). Many also envision huge benefits to be gleaned from nanotechnology in the renewable energy sector, which could hypothetically catalyze the needed breakthroughs to scale up solar energy to meet future demand.[43] Physicist Richard Smalley makes the point very bluntly:

> We are in search of vast amounts of energy and we need a 'technical fix' to the world's energy crisis…The earth is swimming in energy; there is plenty of

[43] Such potential breakthroughs listed by Richard Smalley includes photovoltaics, hydrogen storage, fuel cells, batteries & supercapacitors, photocatalytic reduction of Co2 to produce a liquid fuel such as methanol, nanoelectronics to revolutionize computers, sensors and devices, thermochemical catalysts to generate H2 from water that work efficiently at temperatures below 500°C, CO2 mineralization schemes, nanoelectronics-based robotics, nanomaterial coatings that will reduce the cost of deep drilling and enable HDR (hot dry rock) geothermal mining and nanotech lighting to replace incandescent and fluorescent lights (James Baker Institute, 2005: 11).

> energy there to be had. The only reason we have a problem is that we haven't figured out a technical way to do it cheaply…[Nanotechnology] holds the answer, to the extent that there are answers, to most of our most pressing material needs (quoted in James Baker Institute, 2005: 10).

It is not necessary to buy into all the hype surrounding these technologies, often peddled by entrepreneurs with financial and existential investments in these industries, to accept that they are indeed enabling new vistas of technological creativity that will alter the geopolitical, economic, and ecological landscape, and may in fact provide powerful tools that can help devise solutions to the earth system, economic, energy and food crises. One obvious and important response by ecological economists and other skeptics would be to challenge these optimistic assessments by providing a more rigorous material life-cycle analysis of these technologies and consideration of the rate of innovation and implementation that would be needed to achieve absolute decoupling within the needed timeframe. However, given irreducible uncertainty combined with the "exponential" and "revolutionary" promise of the FIR technologies (Schwab, 2017; Diamandis & Kotler, 2014), such assessments would always be insufficient in the eyes of the techno-optimists. Therefore, an alternative line of response should also be pursued: what if the ecomodernists and techno-optimists are right? What if exponential technologies *do* succeed in decoupling economic growth from total environmental impact while helping to restore damaged ecosystems?

In short, we must highlight how these technological solutions to sustainability crises would intensify the ongoing process known as the "democratization of violence", in which, the "destructive power once reserved to states is now the potential province of individuals" (Blum & Wittes, 2015: 2). Rather than simply a matter of creating new weapons, Gabriela Blum and Benjamin Wittes emphasize that the NBIC3d convergence should be understood as a matter of "whole technological fields – a series of breakthroughs in basic science and engineering" that "facilitate generative creativity in their users to build and invent new things, new weapons, and new modes of attack" (ibid: 39, 7-8). In this sense, as Blum and Wittes emphasize, societies don't just face a "biosecurity" problem or a "cybersecurity" problem; rather, they face "a broader problem of how people will make use of the incredible power these technologies – individually and in integration with one another – will give them" (ibid: 41).

To compound the problem, while NBIC3d technologies empower individuals to kill and provoke systemic chaos unlike any other time in history, they also empower states to monitor the minute details of private and public life and potentially constrict individual and collective freedoms, while the unprecedented molecular threats enabled by these same technologies will likely reinforce governmental efforts to penetrate securitization as deeply as is technologically feasible. Blum and Wittes thus summarize the emerging predicament in the following terms:

> How should we think about the relationship between liberty and security when we both rely on governments to protect us from radically empowered fellow citizens around the globe and also fear the power those same technologies give to governments? (Blum & Wittes, 2015: 13).

Blum and Wittes do not consider how these challenges will evolve in relation to climate change and sustainability crises, and they ignore the possibility that a combination of energy constraints and economic contraction will provide a negative feedback to diminish the severity of these threats. But it should be clear that, in a world of FIR driven resolutions of environmental crises, they would inevitably intensify, and it is thus necessary to take them seriously and consider what new problems and governmental responses they would engender.

Nuclear Security

The threat of nuclear weapons is one of if not the most widely studied problem in the field of security studies, though I will simply focus on the implications of an expansion of nuclear energy for the threats posed by nuclear terrorism, industrial accidents, and sabotage. Since it is questionable that renewable energy would be capable of meeting all of the future energy demands of a growth-oriented capitalist global economy, regardless of achieved efficiencies, it is likely that nuclear energy will need to at least moderately expand to make up for the shortfall. As the well-known ecomodernists Ted Nordhaus and Michael Schellenberger proclaim: "There is no credible path to reducing global carbon emissions without an enormous expansion of nuclear power" (Nordhaus & Schellenberger, 2011). The Deep Decarbonization Pathways Project suggests that nuclear energy may need to be scaled up in the US, China and elsewhere to account for 30 to 60% of total electricity demand (up from 20% today), while the IEA recommends a more modest (but still significant) global expansion from 15% to 25% by 2050 of total electricity by (Pinker, 2018: 147; Sovacool et al, 2016). With developing nations like China, India, Pakistan and others planning to expand nuclear energy generation over the coming decades to meet its growing electricity needs while cutting GHG emissions (Parthemore, 2017),[44] it is important to consider the risks that will be posed by a solution to climate change that relies heavily on nuclear power.

While many anticipate that nuclear power is unlike to take up a greater share of electricity generation than it does today (Sovacool et al, 2016), the risks it poses will

[44] China, for example, has announced plans to build 6 to 8 new reactors per year through 2020 and increase the rate of production thereafter, becoming the world's top nuclear energy supplier by 2030. India plans on ramping up investment in fast breeder reactors in order to rapidly expand nuclear generation capacity to 63,000 megawatts in 2032, while Pakistan has made plans to construct 32 new power plants by 2050 (Parthemore, 2017). Jordan, Saudi Arabia, and Bangladesh are also pursuing nuclear energy, though Parthemore notes that climate changes and geographic constraints may limit their ability to operate water and land intensive power stations (ibid: 47).

expand even if its percentage of total electricity remains constant. This is because old "generation II" reactors, which comprise the majority of reactors now in operation, have a limited lifespan and need to be decommissioned, replaced, or refurbished (Sovacool & Valentine, 2012). This means that the waste generated by earlier reactors remains a problem to be dealt with, since it persists in hazardous form for at least 100,000 years, while new reactors add to the stock of waste and fissile materials in circulation. Thus as Sovacool and colleagues argue, "If we doubled the number of nuclear reactors worldwide, we would double the possibility that countries without weapons might obtain them. No other energy system has such an acute link to weapons of mass destruction" (Sovacool et al, 2016: 258-259). This is because an expansion in nuclear energy infrastructure would not only expand the availability of fissile material that needs to be closely guarded and safely stored, but also increases the number of individuals with access to nuclear knowledge, material, and enrichment capacities who could potentially sell them on the black market to prospective buyers.[45] As Chris Abbott, Paul Rogers, and John Sloboda argue, given that global unrest is likely to increase in the coming decades as the impacts of climate change intensify, especially in countries like China, India, and Pakistan where major buildups of nuclear power are being planned, there will be serious dangers associated with the circulation and storage of fissile materials that are likely to be exploited as opportunities increase (Abbott et al, 2007: 19).

Many are confident that the risk of nuclear terrorism is low, due to the difficulties in acquiring fissile material, the expertise needed to build a bomb, and the challenges of

[45] As noted earlier, nuclear advocates claim that "generation IV" reactors would be capable of surmounting many of these problems by reducing waste quantities through more efficient use of fuel and substituting thorium for uranium and plutonium (which can't be used for bomb-making) (Brand, 2010), though these are not expected to be commercial until 2040 at the earliest (Sovacool & Valentine, 2012: 31). Thus the risks of nuclear proliferation tied to nuclear energy will remain with us at least for the next couple of decades.

delivering and detonating one at a desired target (Brand, 2010). However, an expansion of the nuclear economy would enhance these risks by widening the availability of nuclear experts, fissile materials, nuclear sites, and equipment. While the challenges posed to small groups of non-state actors in building a bomb remain formidable, many highlight the threats posed by much simpler "radiological weapons", which would be capable of dispersing radioactive material across a city block though they would likely not be capable of inflicting massive civilian casualties (Homer-Dixon, 2002). It is also possible that advances in FIR technologies could make it easier for small groups to obtain nuclear materials and fabricate a bomb, since it will reduce the costs of engaging in high energy physics, make the development of smaller scale bombs more feasible, and potentially make specialized components printable with little technical skill (Phoenix & Treder, 2006; Volpe & Kroenig, 2015). While these developments wouldn't make the acquisition of fissionable material any easier, an expanded nuclear infrastructure combined with these new capabilities would reduce the technical and logistical hurdles of obtaining the needed components and fabricating a nuclear weapon. We may not quite get a world with billions of people walking around with nuclear weapons in their pockets, as Blum and Wittes imagine (Blum & Wittes, 2015: 8), and these techniques are likely to be dominated by states and militaries in the coming decades (Kelley, 2017). But as with other FIR technologies (to be explored in subsequent sections), over time they would likely reduce the barriers to access for small groups of would-be terrorists and would certainly make clandestine pathways to a bomb easier for states seeking a nuclear capability (Fey, 2017).[46]

[46] Marcus Fey argues that 3D printing would make controlling nuclear proliferation more challenging for at least 5 reasons: 1) it would significantly increase the indigenous manufacturing capabilities of countries by enabling certain

Finally, there are the risks of accidents and sabotage. Thomas Homer-Dixon, for one, argues that radioactive waste pools associated with nuclear reactors are probably the most lethal targets in the national energy-supply system. Sabotaging nuclear reactors or dispersing waste into the environment would have catastrophic risks, though they would be logistically difficult to pull off (Homer-Dixon, 2002: 60). Nuclear reactors of course pose their own risks outside of human intentionality, though safety features have improved significantly in recent decades (Brand, 2010; Sovacool & Valentine, 2012). Still, MIT researchers estimate at least 4 serious core damage accidents would be almost certain to occur between 2005 and 2055 based on rate of economic growth and nuclear expansion (Sovacool et al, 2015: 257). While for them this poses an unreasonably high accident frequency, given the immense environmental, health, and economic costs such accidents incur, the risks appear even higher when we take into account the effects of increasingly frequent and intense storms, floods, and sea level rises driven by climate change (Parthemore, 2017). Most nuclear plants in operation are "light water reactors" (over 80%), and these are commonly sited next to rivers, lakes, and oceans in order to provide ready access to steady streams of water inputs. With the Fukushima disaster being only most recent and high profile example of vulnerable coastal nuclear power plants, we are almost assured to see more reactor meltdowns driven by flooding as nuclear power expands and climate change intensifies. While any technology has its risks, and the benefits of (relatively) carbon-free electricity may encourage states and

components and materials, which are difficult to obtain due to controlled exports, to be manufactured additively; 2) it would increases a potential proliferator's autonomy by decreasing dependence on imports of, for example, spare parts for energy or other high-tech sectors reduces the effectiveness of international sanction regimes; 3) it may significantly decreases development cycles and lead times to a degree such that "trial and error" may substitute for a lack of engineering skills and expertise in metal-working; 4) it may facilitate the easier transfer of know-how and construction plans due to 3d printing's high proportion of cyber-automation; and 5) it might also decrease the "footprint" of production facilities for nuclear weapon parts, which would make it harder to detect illicit activities (Fey, 2017).

populations to rally behind a nuclear renaissance, the risks of nuclear terrorism would almost certainly increase in such a world, though they would likely not be as challenging or severe as other democratized violence capabilities on the horizon.

Biosecurity

Despite global efforts at harmonization and integration of biosecurity policies, there is no single agreed upon definition of what biosecurity is and what its priorities should be. Nevertheless, we may understand it as a unified though heterogeneous problematic that is concerned with population security from pathogenic microbes, which may be endangered by naturally-occurring disease outbreaks, accidental leakages from high-risk bio-laboratories, or weaponization and intentional deployments by state or non-state actors (i.e. "bioterrorism"). In the present scenario, I will focus on the problem of bioterrorism, since it would be most relevant in a world of readily available biotechnology, synthetic biology techniques, and 3d printing. This is because biotechnology radically enhances the bioterror threat by enabling the manipulation and weaponization of pathogenic microbes at the genetic level, making bioweapons "one of the most serious problems humanity has ever faced" (Guillemin, 2005: 186).

Both the promise and danger of biotechnology, as both its advocates like George Church and alarmists emphasize, is its immense creative potential. In short, the potential for weaponization and range of imaginable attack scenarios created by biotechnologically enhanced bioweapons are theoretically unlimited. In the words of a report from 2005 by the National Academies of Science:

> the number of agents created by the life sciences revolution (e.g., via recombinant and transgenic technology and even synthetic biology) is increasing

> practically exponentially...the number of potentially harmful biological agents is *virtually limitless* (quoted in Vogel, 2008: 234; italics added).

For example, manipulating DNA structures in microorganisms can make certain agents more virulent, improve their resistance to antibiotics and vaccines, make them less detectable by already limited surveillance systems, transform harmless microorganisms into deadly ones, and make pathogens more resilient to diverse atmospheric conditions, thus increasing their lifespan (NAS, 2018). At present these capabilities remain limited and dependent on highly advanced techniques and laboratory equipment, which is why most experts believe there have to date been no mass casualty bioterror attacks (ibid: 116). However, a report by the National Academy of the Sciences notes that improvements in synthesis technology "have followed a 'Moore's Law–like' curve for both reductions in costs and increases in the length of constructs that are attainable", and that "these trends are likely to continue" (ibid: 18-19). Moreover, automated DNA synthesis techniques remove much of the time-consuming and technically difficult aspects of manipulating DNA, further reducing barriers to access (Wintle et al, 2017). And in the future, experts warn that "convergent capabilities" between synthetic biology, information technology, nanotechnology, and 3d printing may enable "sudden" breakthroughs in bio-weaponization (e.g. by improving bio-agent stability and delivery, providing advances aerosolization capability, and accelerating the "Design-and-Build" cycle) (NAS, 2018: 87).

The possibilities of bio-weaponization will expand as these techniques diffuse, which are already enabling the formation of a "DIYbio" movement in which amateur scientists, inventors, and others are increasingly "capable of doing at home what just a few years ago was only possible in the most advanced university, government or industry laboratories” (Bennett et al, 2009: 1109). The new CRIPSR/Cas9 gene editing technique further expands the range of genomic tinkering available to individuals, which has been widely embraced by the DIYbio community as a powerful tool that “makes it easy, cheap, and fast to move genes around—any genes, in any living thing” (Maxmen, 2015). The capacities of DIY biohackers remain limited in important ways, though the trends described above suggests they will continue to increase as barriers to advanced bio-weaponization fall (NAS, 2018). The genomes of many bacteria and viruses, including Ebola, Marburg, smallpox, and the 1918 Spanish flu virus, have been sequenced and deposited in a public online database. Interested buyers can now commercially order pieces of DNA as long as 40,000 bases – longer than genomes of most viruses (SARS is 30,000, Ebola less than 20,000) (Nouri & Chyba, 2011: 458). Thus while the risks are evident, the democratization of these techniques may also facilitate the diffusion and customization of local solutions to environmental and health challenges while enhancing popular participation in the direction of biotechnological evolution away from transnational corporate dominance. As Bennett and colleagues explain:

> The good news is that open access biology, to the extent that it works, may help actualize the long-promised biotechnical future: growth of green industry, production of cheaper drugs, development of new biofuels and the like. The bad news, however, is that making biological engineering easier and available to many more players also makes it less predictable, raising the specter of unknown dangers (Bennett et al, 2009: 1109).

It is therefore clear that these emerging technologies pose a unique kind of “security dilemma”: while their development and diffusion may strengthen local and global capacities to resolve environmental challenges, they may also imperil global security by unleashing uniquely powerful and complex violence capabilities. Synthetic biology is only in its early stages, and governments from the UK to China aim to “accelerate [its] industrialization and commercialization” in order “to drive economic growth” and “develop solutions to key challenges across the bioeconomy, spanning health, chemicals, advanced materials, energy, food, security and environmental protection” (Synthetic Biology Leadership Council, 2016: 13, 4). If calls for emergency action to exponentially expand the green economy indeed accelerate these trends (Falk et al, 2018), then we will soon live in a world where genetically engineered biofuels dramatically increase (perhaps expanding 150% above current levels by 2030, as the IEA calls for) (IEA, 2019a), genetic tinkering with crop varieties is normalized to enhance agricultural resilience, and gene drives are deployed to control old and new disease vectors intensified by climate change[47] (among other potential applications), which would exponentially expand the number of individuals with biotech expertise and access to the needed equipment. Given that, as the NAS notes, “bacteria are routinely modified for a wide variety of beneficial purposes (e.g., to produce biofuels and pharmaceuticals), and the same techniques and knowledge base would likely prove useful for modifications pursued with a more nefarious intent” (NAS, 2018: 57-58), it should be clear that the risks of bioterror attacks will increase (perhaps non-linearly) as the knowledge, techniques, and equipment become more central to economic growth. Therefore, while we have yet to experience a catastrophic bioterror attack, rapid advances in synthetic biology are nonetheless creating a “black swan waiting to happen” (Bennett et al, 2009: 1110), and the risk is that such black swans could become increasingly “normal” if this

[47] It is also likely, as a recent National Academy of the Sciences report warns, that future crises will intensify pressures to deploy CRISPR techniques without a thorough assessment of the systemic risks they pose. In their words: “The presumed efficiency of gene-drive modified organisms may lead to calls for their release in perceived crisis situations, before there is adequate knowledge of their ecological effects, and before mitigation plans for unintended harmful consequences are in place” (Committeee on Gene Drive Research in Non-Human Organisms, 2016: 1).

technology becomes a key engine of economic growth and green technological innovation.

Cybersecurity and Critical Infrastructure

While the bioterror threat may be the most challenging confronting an FIR-dependent global political-economic system, it would also inherit and intensify the accelerating vulnerabilities of our present-day cyber-infused critical infrastructure systems. Critical infrastructure encompasses the food, water, health, energy, transportation, and cyber infrastructures on which the life of capitalist civilization depends, which are increasingly integrated through information networks. As cybersecurity researcher Dave Clemente explains,

> Cyberspace can be visualized instead as a thin layer or nervous system running through all other sectors, enabling them to communicate and function…As transportation intertwines with food distribution and telecommunications, and as these and many others sectors are supported fundamentally by the finance and energy sectors, it is more difficult to draw clear boundaries between critical areas (Clemente, 2013: v).

In this sense, it is clear that cybersecurity is not simply a separate domain but rather one that infuses all other problems, at least given the dominant networked configurations of critical infrastructure systems throughout the global economy. The US Department of Homeland Security defines these critical infrastructures as "the framework of physical structures and cyber information networks that provides a continual flow of information, foods, and services essential to the defense and economic security of the US" (DHS 2004: 1). These have been given heightened prominence since the 9/11 attacks, which drew attention to the ways in which the complex logistical life-support systems on which networked industrialized societies depend could be exploited for potentially catastrophic ends. Thomas Homer-Dixon describes these emerging threats through the concept of "complex terrorism", which is made possible by the growing complexity and interconnectedness of networked societies, and the increasing geographic concentration of wealth, knowledge, and communication links (Homer-Dixon, 2002: 55). From the electrical grid to transportation systems, logistical supply-chains, food delivery networks, pipelines, water filtration systems, nuclear power plants, and many others linked through information networks, these systems present myriad opportunities for non-state terrorists to exploit vulnerabilities with cascading effects.

In this sense, regardless of attempted resolutions of sustainability crises in the next decade or two, it is clear that the cat is already out of the bag in the domains of cyber and critical infrastructure vulnerability. Cybercrime has exponentially increased to the point of costing the global economy an estimated $500-600 billion per year, while new vulnerabilities in civilian infrastructures continue to be discovered and exploited far more quickly than they can be secured (CGI Group, 2014; Goodman, 2016). The Department of Homeland Security reported nearly 200 attacks on critical US infrastructures in 2012, including attacks on oil and gas pipeline operators and nuclear power plants, while just 9 attacks occurred in 2009 (Seabrook, 2013). Meanwhile, the "Internet of Things" (IOT) – referring to the network of interconnected devices that emit data to the cloud to enable network feedback and coordination – has already expanded to the point that there are more such devices on the planet than humans, creating far more potential points of entry and attack vectors for hackers (CGI Group, 2014). While a "cyber pearl harbor" has yet to materialize, and the number of civilians killed by cyberattacks remains zero (Rid, 2012), non-lethal risks like data theft, identity fraud, election-tampering, and a new horizon of cybercrime have raised the profile of cybersecurity to a top priority for governments around the globe (Goodman, 2016).

While we are thus dealing with an already significant dimension of the Planetary Problematic, we should consider the risks associated with the incipient Internet-of-Things (IOT), which is a key component of the solution-set offered by techno-optimists for decoupling economic growth by dramatically improving efficiencies in energy, transportation, and agriculture (Falk et al, 2018; World Economic Forum, 2018). For one, one of the prerequisites of a future renewable energy system capable of providing at least 80% of projected electricity demand (assuming growth continues according to the imperatives of a capitalist economy), would be the creation of national or regional "smart grids" in which energy surpluses in areas with lots of wind and sun at a given time can be transmitted to areas with energy deficits. Renewables like solar and wind have the potential to create more resilient energy grids due to their decentralized production capacities and modularity (Heinberg & Fridley, 2016).[48] However, the more widely networked a "smart" renewable energy grid becomes, the more vulnerable it would be to cyberattack and sabotage. In particular, the efforts of Cisco and others to enhance the efficiency of smart grids via the IOT would intensify these vulnerabilities even more. In this vision, the smart grid would form "an intelligent network of power lines, switches, and sensors able to monitor and control energy down to the level of a single lightbulb", which would be enabled by IOT connected sensors that "monitor energy use and manage demand, time shifting noncritical applications like delaying the start of your dishwasher

[48] For this reason, among others, Heinberg & Fridley advocate for decentralized renewable energy grids, which would entail lower energy usage but greater resilience: "Decentralizing the grid would encourage energy use more in line with natural flows of renewable energy…households/communities would be more self-sufficient, and the system would entail less complexity and fewer interdependencies, resulting in less vulnerability to breaks in a brittle system" (Heinberg & Fridley, 2016: 61-62).

to the middle of the night, when energy is cheaper" (Diamandis & Kotler, 2014: 169-171). In other words, every connected device – from iphones and laptops to dishwashers and microwaves – would become a possible point of entry for hackers to the overall network, in this way dramatically expanding possible cyber-attack vectors (Goodman, 2016: 287; IRENA, 2019: 58).

The IOT is also envisioned as a possible to solution to traffic congestion and fuel efficiency for the future fleet of self-driving electric vehicles that are set to (potentially) transform the market over the next decade (Arbib & Seba, 2017). As John Urry describes:

> cars, roads, and buildings are being increasingly rewired to send and receive digital information in newly re-configured intelligent transportation systems (ITS). With the increase in the use of sensors future automobiles may resemble computers with wheels rather than cars with chips…adaptable learning 'autocars' may develop to integrate into the software based urban infrastructure. A tipping point may occur that coerces individual mobility into an assemblage of 'smart' technologies (Urry, 2008: 346).

While advocates of "smart" cars and "smart" cities are enthusiastic regarding the possibilities for improved energetic and economic efficiency, it would also leave vehicles vulnerable to remote hijacking, as researchers Chris Valasek and Charle Miller demonstrated in 2014 by taking control of a 2014 Jeep Cherokee. US Senator Markey's 2015 report reveals that such vulnerabilities are endemic across the industry, which are set to intensify if the self-driving car market expands as anticipated (Markey, 2015). Additionally, as Urry, notes, such a system would also entail a "digital panopticon" with satellite tracking, ubiquitous CCTV cameras, and a deepened embedding of surveillance throughout urban environments and beyond (Urry, 2008: 348). Finally, adding further to the IOT-hype, a World Economic Forum report proposes deploying it to create "precision agriculture" systems, which could link farms with global positioning systems and weather data collection to monitor water and soil conditions while enabling farms to automatically optimize inputs (World Economic Forum, 2018). It claims that these technologies could boost yields, reduce emissions, and improve water efficiency while also making it possible to track food products through supply chains and remotely control their transport and storage environments, thereby reducing food waste (ibid: 10, 18).

If these IOT-powered systems become normalized in the coming years and decades, there would be no end to the digital playground for would-be hackers to wreak havoc with our food, energy, transport, health, and other critical infrastructure systems, whether they come from states, criminal organizations, non-state terrorist networks, or anonymous trolls. Cybersecurity analyst Mark Goodman effectively captures the scale the problem:

> we cannot even adequately protect the standard desktops and laptops we presently have online, let alone the hundreds of millions of mobile phones and tablets we are adding annually. In what vision of the future, then, is it conceivable that we will have any clue how to protect the next fifty billion things to go online? (Goodman, 2016: 301-302).

In short, while the expansion of cyber vulnerabilities is already stressing if not overwhelming the defense capacities of governments, corporations, and public utilities, it is also practically assured that these vulnerabilities will continue to expand if the global economic relies on smart energy grids, big data, and the IOT to maximize energy efficiency and sustain compound growth.

State Securitization and Totalitarian Dangers

The above technological trends not only enhance the destructive power of non-state actors, but also the power of the state itself, which may be in the process of actualizing "Promethean" powers of securitization and control. FIR technologies may not qualitatively transform state power individually, though their *convergent* character could offer immense power to states able to systematically harness these capabilities for the ends of surveillance and militarization. Unsurprisingly, such capacities are being intensively pursued by leading states. In particular, the US and China appear to be engaged in an AI arms race, with China aiming to create a $150 billion AI industry by 2030 and the Pentagon seeking to triple its AI warfare budget to match China's ambition (Ashizuka, 2019). Military robotics is also a key field of competition, with worldwide spending tripling between 2000 and 2015 from $2.4 to $7.5 billion, and which some estimate will double again by 2025 (Allen & Chan, 2017: 14). The US has also spent $29 billion on nanotechnology research since 2001, with about 20% of its investments involving military applications (National Nanotechnology Initiative, 2019). A short list of potential military applications includes powerful and lightweight body armor, microscopic and networked nano-bots with capacities for "swarm intelligence", and more compact and powerful chemical and nuclear weapons (Drexler, 2013: 260).[49]

The full extent of the capacities they are likely to unleash cannot be known in advance, though it seems probable that they could become an "axial" capability of states. As Deudney describes, an axial capability is one that has the capacity to dominate an entire system due to its unique character (Deudney, 2007: 44). While FIR technologies

[49] See also the Royal Society's 2012 report on the use of neuroscientific research by the US and UK militaries. Potential applications include psychopharmacological enhancements to improve the performance of soldiers on the battlefield, as well as advanced brain-machine interfaces that can integrate soldiers more smoothly into weapons systems, a long-standing military dream (Royal Society, 2012).

may not offer axial capabilities individually, their *integral* character is such that they could collectively offer an axial advantage to states able to systematically harness their capabilities. This could take the form of a *globally networked and nano-IOT-AI powered system* harnessing vast capacities for force-mobilization and information gathering and processing. By integrating nanotechnology, the IOT, big data, and robotics while harnessing the processing power and flexibility of advanced AI, states may in this way be in the midst of unleashing technological capabilities that will enable them to informationalize and monitor humans populations while mobilizing destructive power with an unprecedented degree of precision and sophistication. Such an axial advantage could also involve control over orbital space, which may be facilitated by developments in nanotechnology that will make space exploration and militarization cheaper and more efficient (Deudney, 2020). In conjunction with other advances in nanotechnology, biotechnology, and cognitive science, which will enable more sophisticated and ubiquitous sensors and perhaps even make it possible to police mental states (at least to a limited extent),[50] these developments look to be a dream come true for authoritarian regimes.

However, without speculating on the future, we can already see how governments and militaries are taking advantage of the emerging global information infrastructure to enhance control over the security environment, which will only become more extensive and intensive by integrating bio and nanotech capabilities. In fact, the metastasizing US security state is already in process of forging an incipient Techno-Leviathan – a "global-

[50] A taste of what the future might harbor can be seen in DARPA's $4 million project called "Battlefield Illusion," which seeks to investigate technologies that can "manage the adversary's sensory perception" (Royal Society, 2012). While this may be a long way from "mind control", the latter could become a real prospect, at least in a limited form, as knowledge of the brain advances and the physical mechanisms undergirding human consciousness and cognition are better understood.

surveillance-state-in-the-making" – whose drive for informational omniscience is pushing it beyond territorial boundaries in an effort to control the global infosphere and erode all pretense of legality and democratic oversight (Engelhardt, 2014: 107). And we are seeing comparable developments in China, where advances in AI, the IOT, and big data are being used to construct a "citizen score" system that incentivizes "good" (i.e. regime-friendly) behavior and punishes citizens for critical thinking (Mitchell & Diamond, 2018). Over 75 countries are already using AI technologies for surveillance, facial recognition, and "smart policing", with Chinese companies supplying AI surveillance technology to 63 countries (36 of which are part of its Belt and Road Initiative) (Gaffney & Mutsvairo, 2020). Thus while securitization trends in the US, China, and elsewhere should already give us pause, they will only become more extensive and intensive by integrating increasingly advanced AI, algorithmic surveillance, networked IOT sensors, and even neuro-technologies over time (Amoore, 2013). As the oft-cited technologist Bill Joy wrote in his famous piece from 20 years ago, which may turn out to be more prescient than any of us would like: "it is no exaggeration to say we are on the cusp of the further perfection of extreme evil, an evil whose possibility spreads well beyond that which weapons of mass destruction bequeathed to the nation-states" (Joy, 2000).

Conclusion

The above overview does not intend to exhaustively cover every element of the planetary crisis convergence, which could also include crises of mental health, emerging diseases and pandemics, antibiotic resistance, political polarization, neo-fascist revival, militarized borders and the securitization of migration, "state failure" and civil war, among others. However, it covers some of the key dimensions that will be most critical in forcing a catastrophic discontinuity beyond the current configuration of world politics in coming decades. Though it remains an "agglomerationist" analysis to the extent that it looks at specific crises in relative isolation, it also highlights connections between them in order to give a preview of how they constitute an emergent "problematic". These relations and feedbacks will be elaborated further in chapter six, but for now I have given an overview of the planetary crisis convergence in order to orient our analysis of existing approaches to these crises. How successful has the discipline of IR been in helping us understand and respond to this predicament? This will be the subject of the next chapter.

Chapter Two: Planetary Crisis, Disciplinary Limits: The Field of IR

This chapter will assess the adequacy of existing approaches in the field of IR to engage with the planetary crisis convergence. As noted in the introduction, there is a long history of critical diagnoses of world politics as headed towards catastrophe in the absence of structural transformation (Herz, 1957; Wagar, 1967; Morgenthau, 1967; Falk, 1971; Sprout & Sprout, 1971; Pirages, 1978; Deudney, 2007). Many of these analyses focus on the problematic of nuclear weapons in an anarchic international system, arguing that more radical restraints on nation-state sovereignty would be needed to short-circuit the security dilemmas that breed mutual suspicion, nuclear proliferation, and the threat of an accidental or intentional nuclear conflict. The threat of environmental degradation and resource depletion took on increasing salience in the 1970s, due in part to the growing influence of the environmental movement and the experience of the 1973 oil crisis (Pirages, 1978). These experiences facilitated the dawning recognition within the discipline that the global economy and world order itself were built on biophysical foundations; should these foundations deteriorate, then world order would be likely to undergo a major crisis and period of transformation (Pirages, 1978; Falk, 1971; Sprout & Sprout, 1971).

Nearly fifty years later since the rise of environmental awareness in the industrialized world, ecological concerns have become integrated in established sub-fields within the discipline of IR, from Global Environmental Politics to Environmental Security and the geopolitics of energy. Yet a "biophysical blindness" – or what Deudney calls the eclipse of "naturalist social science" by social science – remains pervasive throughout most of the discipline, as well as the social sciences more generally, where biophysical parameters like climate, energy, biodiversity, oceans, and ice are sometimes acknowledged but rarely figure in as fundamental constituents of the present and future dynamics of world politics (Deudney, 1997; Connolly, 2017a). This biophysical blindness may appear excusable when theorists focus on problems like war, nuclear proliferation, diplomacy, identity, trade, and other issues *seemingly* distant from biophysical concerns – though it is not hard to see that all of these processes are fundamentally entwined with the constitution and reshaping of the earth (Burke et al, 2016; Grove, 2019). In particular, when IR scholars are concerned with global systemic questions such as the current crisis and future of world order, then this blindness becomes a significant (arguably fatal) analytic constraint. It is as if a family were arguing as their house burns and its structural foundations erode, while analysts focus on the dynamics of interaction between the family members and their personalities, perhaps focusing on the power struggles between two competing blocs within the family, yet ignoring the fire itself.[51] Thus they believe that the house will survive indefinitely (what I will call "continuationism"), though certain family members may become more powerful and new norms might be constructed to help them cooperate more effectively.

Of course, as just mentioned, there *are* an increasing number of approaches that do recognize the fire and have made it central to their analysis of world politics. However, to extend the metaphor a bit, we might say that many of these approaches either focus on fires within specific rooms of the house ("isolationism"), or aggregate data about the fire and its effects in different rooms and on various dimensions of the house's structural foundations, but without thereby *synthesizing* this information into a consistent narrative that understands the implications for the house as a whole

[51] This metaphor is useful though imperfect, since it doesn't capture how the practices through which the family members reproduce themselves daily are themselves the key cause of the fire.

(“agglomerationism”). Without providing a synthetic and systematic narrative of the fire, many of these analyses are then led to propose incrementalist, voluntarist, or ethical solutions, all of which tell us little about the systemic transformations that would be needed to actually put out the fire, keep the house from collapsing, and/or rebuild it from the bottom up. Finally, some scholars focus on describing in great detail how the family members themselves discursively construct and respond to the fire, while bracketing questions about the reality of the fire itself (“discourse-centrism”).

I will in this way suggest that it is possible to identify tendencies within the field of IR that either blind theorists to the complexity of the planetary crisis and the likelihood of an imminent catastrophic discontinuity, or hinder their capacities to analyze its causal drivers and feedbacks, anticipate its possible trajectories, and propose viable systemic responses. Biophysical blindness is the most obvious and pervasive tendency throughout the discipline as a whole in this regard, but we can also perceive more subtle tendencies that characterize those who *have* moved beyond such blindness. This is the case with those who focus on specific problems (e.g. climate change or economic crisis) in isolation from other dimensions of the planetary problematic (“isolationism”); who aggregate insights regarding these numerous dimensions without producing a synthetic and systematic analysis of the over-arching crisis convergence (“agglomerationism”); or who focus on how the problems are framed by hegemonic agencies while bracketing the reality of the problems themselves (“discourse-centrism”).

As noted in the introduction, it is difficult to structure an engagement with the field of IR on the problem of the planetary crisis convergence, since this problematic *as a whole* has hardly received attention. Thus there is no other way to proceed than to engage scholars who have addressed one or more of its dimensions, or, on the other hand, to engage scholars whose primary questions (e.g. "what is the future of world order?") can hardly be answered without attention to the crisis convergence. One might argue that I critique many of these theorists for *not doing what I believe they should be doing*, rather than engaging them on the terms their work sets for itself. I would reply that in certain cases this is true (especially regarding the isolationists and discourse-centrists), in other cases only partly true (e.g. the biophysically blind and certain discourse-centrists), and in others it is false (often, but not always, in the case of the agglomerationists). However, it should be emphasized that my critique is leveled primarily towards the *discipline as a whole* (an emergent entity that is more than the sum of its parts), rather than simply the individual thinkers and approaches that compose it. In short, the critique is that IR has so far failed to provide a framework of analysis that is capable of perceiving the coming catastrophic discontinuity in world politics, analyzing its causal drivers, mapping its possible trajectories, and thinking through the contours of viable systemic responses that go beyond the focus on individual problem-domains. Thus many of the theorists I engage with in this chapter are useful both for providing partial insights into the planetary crisis and its numerous dimensions, as well as for illustrating what I find to be problematic disciplinary tendencies, though this is not meant to deny the value of their work taken on its own terms.

I will begin with a brief overview of the tendency towards biophysical blindness within the emerging literature on the future of world order, which results in continuationist biases. I will then explore the tendencies towards isolationism and agglomerationism in the sub-fields of Global Environmental Politics and Environmental

Security. Next, I will engage with work in Foucauldian CSS on contemporary crisis and resilience, illustrating its tendency towards discourse-centrism. Finally, I will suggest that certain engagements with Complexity Theory, posthumanist theory, and the earth system sciences point the way towards a more effective theoretical framework beyond the disciplinary limits of IR, though they should be deepened in part through an engagement with Marxism and in part through the development of a multi-dimensional ontology based on Deleuzian assemblage theory, which I will undertake in chapters three and four respectively.

Biophysical Blindness: Debates on the Future of World Order

In one sense we should not be surprised that much the disciplinary IR mainstream fails to integrate biophysical parameters in their analysis, and therefore appears blind to the coming systemic rupture. Despite countless challenges and openings over the past 3-4 decades, IR for many remains the study of interactions and conflict between states and the international institutions that mediate them. Within these approaches, "change" simply entails either shifts in the balance of power and/or the rise and fall of hegemons (for realists) (Waltz, 1977; Gilpin, 1982); or the emergence of new norms and institutions to mediate these relations, the inclusion of new members in existing institutions, or structural changes within existing institutions (Keohane & Nye, 1977; Colgan et al, 2012). However, without taking biophysical parameters into account, at best merely acknowledging them as important problem-domains requiring international cooperation to resolve (e.g. Buzan & Lawson, 2014; Haas, 2017), these theorists are led into a continuationist bias that that is unable to imagine much change beyond a decline in cooperation and/or shifts in power between states, and assumes that 21st century problems can be solved without any deeper structural transformations.

In this sense, by "continuationism" I mean the assumption that there will be no deep transformations in the political-economic structure of world order in the foreseeable future. Continuationists, in this sense, do not expect much change beyond a decline in cooperation and/or shifts in power between states and often assume that 21st century problems can be solved without any deep political-economic transformations in world order. Following Richard Falk and Jörg Friedrichs, it characterizes approaches – whether of realist or liberal stripes – that depict the future as "essentially confined to an incremental continuation of the past" (Falk, 2016: 102), or that "project past economic growth and technological progress" indefinitely into the future (Friedrichs, 2013: vii). In this section I will for the most part focus on what could be called "liberal continuationism", though it is possible to identify multiple varieties of continuationism in IR. Realism, for example, could be seen as an "ultra-continuationist" school of thought that emphasizes the timeless reality of great power politics and cyclical patterns of rising and falling hegemons (Waltz, 1979; Gilpin, 1982). Liberals, on the other hand, tend to believe in the indefinite continuation of liberal notions of progress based on economic growth, "free trade", and technological innovation (Ikenberry, 2011; Doyle, 1986). While some liberals acknowledge that the liberal order may "collapse" into an order defined by greater conflict and fragmentation (Ikenberry, 2018), they do not consider the possibility that this "collapse" could entail a breakdown of the material-energetic and ecological foundations of global trade, economic growth, and technological progress, rather than merely a fragmentation of international cooperation. Thus while different scholars have varying assumptions regarding *what* precisely will continue, we can see that most (if not all) of them take for granted the indefinite continuation of global capitalism and the endless pursuit of economic growth on which its stability rests.

This problem is most apparent in approaches to the study of "world order", which investigates changes in the practices, institutions, and norms through which particular patterns of inter-state behavior are regulated and reproduced (Allan, 2018: 5; Ikenberry, 2011: 13; Haas, 2017: 22). While the literature is vast, we can roughly distinguish between approaches that focus on the crisis of the contemporary liberal order and rise of protectionism (Ikenberry, 2018; Haas, 2017; Colgan & Keohane, 2017), the shift of geo-economic power to East Asia and potential for counter-hegemonic conflict (Mearsheimer, 2018; Layne, 2018), and the rise of a "decentered globalism" (Paupp, 2009; Buzan & Lawson, 2014; Acharya, 2015; Hurrell, 2018; Stuenkel, 2017). John Ikenberry, for one, argues that recent shocks to the liberal order, from Brexit to the Trump election, can be explained as in part a "crisis of authority" and in part a "crisis of social purpose" resulting from the end of the Cold War and the entrance of a wide diversity of states into the order (Ikenberry, 2018). Rather than a "crisis in the deep principles of the order itself" (Ikenberry, 2011: 6), Ikenberry believes that contemporary problems – from rightwing populism to climate change – are no more challenging than previous threats to the liberal order and can be solved without any transformations in the political-economic principles of the order itself (Ikenberry, 2018: 22). He writes:

> The liberal international project has travelled from the eighteenth century to our own time through repeated crises, upheavals, disasters and breakdowns—almost all of them worse than those appearing today…The appeal and legitimacy of liberal internationalism will depend on the ability of the United States and other states like it to re-establish their ability to function and to find solutions to twenty-first-century problems (ibid: 22).

Others argue instead that world order is likely to devolve into regional spheres of influence. Buzan & Lawson, for example, argue that we are today witnessing the emergence of a “decentered globalism” in which “no state will be able to replace the United States as a superpower, because none will be able to acquire enough relative power to dominate the system as a whole” (Buzan & Lawson, 2014: 75). They claim that this will usher in a multipolar world in which the core problematic becomes one of managing the relations between diverse modes of capitalist governance, with the hegemony of capitalist economic organization being firmly settled for the foreseeable future (ibid: 72). While realists argue that the decline of American leadership will usher in a world of renewed regional rivalry and potentially hegemonic war (Mearsheimer, 2018; Layne, 2018), others argue that a more multi-polar or “posthegemonic” world offers opportunity for more egalitarian cooperation between the global north and south (Acharya, 2015; Hurrell, 2018; Stuenkel, 2017).

The problem with these approaches is not that they are unaware of biophysical challenges like climate change; many of them explicitly recognize it as a significant problem, though they believe that it will reinforce the tendency towards cooperative problem-solving and international stability (Ikenberry, 2018; Buzan & Lawson, 2014; Haas, 2017). The primary problem, one that characterizes the vast majority of approaches in IR, is that they do not sufficiently appreciate how world order is itself built on biophysical foundations: namely, a stable earth system, productive agricultural systems that are themselves dependent on a stable earth system, a massively complex and globally networked technosphere, and uninterrupted flows of fossil fuels to sustain the continuous operation of this technosphere (Deudney, 2018; Bousquet, 2015; Ahmed, 2017; Mulligan, 2010; Homer-Dixon, 2006). Anthony Burke and colleagues effectively capture the limits of these debates when they write:

> Important contemporary debates about the dissipation of American power, the structure of world order, or the rise of China and the BRICs, may acknowledge that climate change is a issue of normative significance and diplomatic contestation, but they do not grapple with the gravity of the changes to the biosphere that climate change will wreak or grant the climate an independent agency that will exceed the agency of any state, group, or the state system itself (Burke et al, 2016: 15).

As Shane Mulligan similarly argues, drawing on ecological political theorists like William Ophuls, these approaches assume that the international system is "capable of adapting to any changes in its material conditions", though they ignore the fact that the liberal-capitalist order was itself "the product of (an era of) abundance" and will thus be severely challenged to reproduce itself if (or when) such conditions disappear (Mulligan, 2010: 138-139).

In this sense, Ikenberry, Buzan, and Lawson, among many others, appear unaware of the profound challenges that the destabilization of the earth system and geological depletion will pose to the stability of capitalism and world order more generally. Ikenberry, in thinking that contemporary challenges to the liberal order are no greater than past crises, fails to grasp the qualitative novelty of the 21st century planetary crisis, which not only stresses international cooperation but more fundamentally erodes the biophysical foundations of international trade, transportation, social reproduction, consumption, and even communication[52] on which the liberal order is built (Mulligan, 2010; Di Muzio, 2015). Therefore, rather than simply requiring a rejuvenation of

[52] Not only is the global communications infrastructure vulnerable to hacking, cascading system failures, extreme weather, and sea level rise (which threatens to inundate coastal fibre optic cables in the coming decades, which are not waterproofed) (Durairajan et al, 2018); it also highly dependent on fossil fuels and increasingly scarce resources – from thousands of electricity-intensive server farms to rare earth minerals and energy-intensive material fabrication plants (Greer, 2009: 155).

international cooperation and a shift of responsibilities *within* the order, Ikenberry downplays the likelihood that adequately addressing these crises will require a transformation in the "deep principles" of world order – particularly the core principle of economic growth (Kallis & Hickel, 2019; Parrique et al, 2019).[53] While Buzan and Lawson recognize that high levels of debt, weak growth, and the potential for renewed financial contagion are a "cause for unease" concerning the future of the capitalist economy, they appear to think that the primary source of instability is the concern is that authoritarian states are "not fully committed to capitalism" (Buzan & Lawson, 2014: 88). Even without taking account of biophysical parameters, this perspective remains overly sanguine regarding the health and sustainability of global capitalism; and once we take the former into account, a catastrophist horizon inevitably emerges, along with the need for "fundamental shifts" to match the "fundamentals of the *new normal*" (Princen, 2010: 9).

One of the more mainstream analyses that *begins* to move beyond biophysical blindness is that of Richard Haass, who tackles the emergence of what he calls the "new world disorder" (Haass, 2017: 5). Haass's analysis of the crisis of liberal internationalism is broader than most, which emphasizes the convergence of trends that include increased rivalry between major powers, a growing gap between global challenges and responses, the potential for conflict in several regions, and political dysfunction in many states (in particular the U.S.) (ibid: 6). He is not unaware that world order is headed for a kind of qualitative transition, but for him the emerging disorder is a result of the steady erosion of

[53] This is not to deny that certain principles on which the liberal international order has been constructed – notably recognition of shared functional interests in economic cooperation, security, and environmental protection – have been foundational and beneficial to international problem-solving efforts and should be built upon in any future world order (see Deudney, 1998). I merely want to demonstrate that the political-economic principles on which this order has been constructed are deficient in relation to the planetary crises we confront.

widely shared rules and principles, and processes for adjusting and applying these rules and principles, governing the relations between states (ibid: 103). His analysis encompasses many of the key biophysical challenges facing world order – including the diffusion of technological capacity into the hands of more actors than ever before, nuclear proliferation, a largely ungoverned cyberspace, an inadequate response to climate change, and the potential for global pandemic disease (ibid: 210-211).

Thus while Haass begins to move beyond biophysical blindness, these processes remain a background context of disparate problems that simply require more international cooperation, rather than basic and unruly constituents of world order whose transformations can provoke catastrophic discontinuities in world politics. This leads Haass into fairly superficial descriptions of these various problems, treating them more as external stressors rather than symptomatic expressions of a fundamentally unsustainable world system. For example, on the issue of climate change, Haass more or less says, regarding the Paris Agreement, that *it's a step in the right direction, but we should do more* (ibid: 245). There is no account of the rate of emissions reductions needed to stabilize the climate system, and no appreciation of the difficulties (if not impossibility) of attaining this within a continuously growing economic system. Haass is also aware of the importance of oil for the global economy, though for him the problem is simply one of geopolitical instability in the Middle East creating potential shortfalls of supply, rather than a longer-term trend towards net energy decline and correspondingly volatile oil markets (ibid: 270). And his analysis of the economic crisis is limited to bemoaning incipient challenges to so-called "free trade" (ibid: 248-249), rather than understanding the underlying structural dysfunctions of the global economy that are giving rise to such challenges, such as long-term declines in productivity, intensifying inequality and weakening consumer demand, growing financialization, accumulating private and public debt, and an unaccountable transnational financial-corporate plutocracy concerned more with wealth protection than the stability and survival of capitalism (Foster & McChesney, 2013; Streeck, 2017). While Haass is right that resolving these problems will require shifts in the nature of sovereignty, this only begins to scratch the surface of the changes that will be required – from the structure of the global economy to patterns of consumption, energy use, food production, security governance, and technology regulation – if something like a stable "world order" is to remain viable in the coming decades.

Some might argue that we shouldn't fault these theorists for focusing on a specific understanding of world order, one that focuses on the rules and institutions that mediate inter-state relations, and shifts in the nature of this order. However, I would respond that this narrow perspective reinforces an extremely narrow understanding of the contemporary crisis of world order and leads only to the articulation of superficial solutions, at best taking the form of an elite managerialism that is little concerned with the structures of political-economic power and exploitation at the root of this crisis. Analysis and understanding of the "crisis of liberal international internationalism" and future of world order are too important to be left to such circumscribed ontologies and analytical frameworks. Instead, as the planetary crisis convergence outlined in the previous chapter should make clear, we need a more multi-dimensional form of analysis that not only integrates biophysical parameters and accounts for the possibility of catastrophic discontinuities in the structure of world order (Deudney, 2018), but also enables us to engage with transformative agencies at multiple scales of the international system. The next set of literatures I engage with begin to move in this direction though remain beset by a different set of limitations, to which I now turn.

Isolationism and Agglomerationism

In this section I will provide an overview of the main tendencies that emerge once IR theorists begin to move beyond biophysical blindness. These can be called isolationism and agglomerationism, which both follow from a reductionist ontology that separates the different components of world political reality (e.g. "the environment", "the global economy", "international security") into separate problem-domains requiring individualized analytic and practical responses. While isolationism simply focuses on one of these chunks of reality, agglomierationism aggregates information about these various problems while conceiving them separately (i.e. "now I will cover this problem…now that problem…", etc). As a result, these approaches are unable to think *systemically* about the global challenges we face – including their causal conditions, possible future trajectories, and viable systemic responses.

Rather than going through these tendencies individually, I will give an overview of the key subfields of IR that have begun to engage with the problematic of planetary crisis and show are they are actualized within these approaches to varying degrees. In particular, I will focus on approaches that engage with the problem of environmental crisis, since this is arguably the deepest and most encompassing dimension of the planetary problematic. It would of course also be possible to illustrate the pervasiveness of isolationism among approaches to the global economic crisis (Wallerstein et al, 2013;

Streeck, 2017), the energy crisis (Yergin, 2011), and non-state terrorism (Blum & Wittes, 2015), since isolationism is simply the norm of social scientific inquiry. Engagements with environmental crisis in the discipline of IR will be the focus for reasons of both succinctness and for demonstrating problems that crop up when analysts ignore the broader crisis convergence. The sub-fields of Global Environmental Politics (GEP) and Environmental Security can be considered the key IR literatures that have so far investigated the implications of environmental change and the climate crisis for world politics, and will thus be the focus of analysis.

Global Environmental Politics

While it had its roots in the path-breaking work of Richard Falk, Harold Sprout and Margaret Sprout, Dennis Pirages and others in the 1970s, the subfield of Global Environmental Politics (GEP) has taken off in the past two decades as the problem of climate change and environmental degradation has taken on an increasing salience in world politics (Dauvergne & Clapp, 2016). GEP investigates the processes and implications of environmental degradation in all its forms (from climate change to deforestation, biodiversity loss, pollution, over-fishing, and ozone depletion) and studies governance responses from local to global scales for addressing these challenges (Princen, 2008). In particular, GEP scholars in the past couple of decades have focused on the workings of multilevel governance schemes, the emergence and predominance of market-based governance mechanisms, and the ascent of climate change as the overarching concern for environmental governance (Clapp & Dauvergne, 2016: 2-3; Bernstein, 2002). While climate governance has undoubtedly been the primary focus, GEP also engages broader debates surrounding the incipient geological epoch known as the "Anthropocene", in which human practices have become a planetary force of transformation (Crutzen, 2002; Hamilton, 2016; Harrington, 2016). Many in the field of GEP thus recognize the need to grapple head on with the implications of "a world in the throes of massive and violent transformation, with humanity, unsteadily, at the helm" (Nicholson & Jinnah, 2016: 7), while envisioning new forms of global governance that would be capable of regulating our planetary metabolism and preventing transgression of planetary boundaries (Princen, 2010; Biermann, 2014; Stevenzon & Dryzek, 2014).

While the subfield of GEP encompasses a vast variety approaches to various environmental problems, I will focus here on influential approaches that address the problem of climate crisis, or the Anthropocene more generally, while attempting to propose viable systemic solutions. I will focus in particular on the work of David Victor, Frank Biermann, and Thomas Princen, due to their prominence in the field, the over-arching ambition of their analyses, and the fact that they articulate distinct positions on the continuum of ecological radicalism – from status quo oriented, to more progressive yet reformist, to more transformational. Despite their diversity and the unique strengths and limitations of each, I will propose that the tendencies towards isolationism and agglomerationism, run through them all to varying degrees, which leads more generally to a limited capacity to map the planetary crisis convergence and propose viable systemic responses.

David Victor is one of the preeminent liberal analysts of climate governance, chairman of the Global Agenda Council on Governance for Sustainability at the World Economic Forum and a co-chair of the Brookings Initiative on Energy & Climate. It is worth critically engaging his analysis at length, not only due to its prominence in the field but also because it exemplifies the implicit contradictions of mainstream/liberal (continuationist) analyses of climate change. In short, while Victor to some extent takes us beyond biophysical blindness, it remains continuationist by failing to comprehend the structural transformations necessary to stabilize the earth system (or that will be forced upon us if we *fail* to make these needed transformations).

From the beginning, it is easy to see a continuationist bias at work in Victor's analysis, since it assumes that climate change can and must be solved within current the constraints of current political-economic structures and ways of life. While this continuationist bias is not unrelated to his isolationist analysis of the problem (i.e. that he ignores the intersections between climate change, economic stagnation, and energy depletion), it also flows from a flawed understanding of the climate problem even taken on its own terms. For one, Victor claims that "truly stopping global warming will require cutting emissions by half over the coming few decades" (ibid: xxx). While debate continues over the urgency and needed speed of emissions cuts, Victor's framing of the problem is significantly weaker than the IPCC's recommendation to cut emissions to *net* zero *by 2050* to hold global temperature rises at 1.5°C (IPCC, 2018), which is itself arguably too conservative (Rockström et al, 2017). He notes that strict emissions caps would be needed to prevent dangerous climate thresholds, and that this may require tight caps that are too costly for companies to adjust. He therefore concludes that emissions taxes are the best policy instruments, since they will impose fewer costs on firms and be less disruptive for the global economy as a whole (Victor, 2011: 63-65). It is thus not surprising that he accepts the likely eventual necessity of geoengineering (ibid: 21), and even claims that many poor countries will simply need to be abandoned, since it is simply not profitable for investors to invest in their public infrastructure and adaptive capacity (ibid: 185). Overall, Victor appears indifferent to the fact that that the structure of the global economy he hopes to sustain – its dependence on compound growth, single-minded organization around the profit-motive, and domination by tightly networked transitional financial-corporate plutocracy – is the primary driver of the problem he claims to address. Rather than suggesting that perhaps the global economy should be restructured so that the climate can stabilize, populations throughout the global south can survive, and indigenous and many other ways of life might continue, Victor instead appears to accept that these are all expendable to the over-arching engine of economic growth.[54]

While Victor is an isolationist in that he does not consider how economic stagnation will impede efforts to resolve climate change, or how climate change may force an end to economic growth later this century if the Paris Agreement targets are exceeded, the deeper problem is that his analysis is caught within an inescapable contradiction. Either his approach must accept the inevitability of climate catastrophe (i.e. we simply can't stop runaway climate change without sacrificing economic growth, so we need to accept the former), or downplay the severity of the problem in order to render it apparently tractable within his narrow framing. This contradiction is made strikingly clear by the fact that he praises the Paris Agreement as a "success", while also acknowledging that there is no way it would be able to limit global warming to 2°C

[54] Lest I be accused of being ungenerous, it is worth quoting him at length: "The blunt fact is that in very poor countries infrastructure is not that valuable; long-lived infrastructures are rare. Indeed, these countries are poor in large part because they lack the governing institutions needed to encourage stable, long-term investment in infrastructure and public goods. Thus in crass economic terms, there isn't much that is worth protecting in comparison with higher value assets elsewhere in the world. Outsiders, attentive to costs and benefits in a moral calculation, will find there isn't much they can do to be helpful" (ibid: 185).

(Victor, 2015); in short, it is a "success" based on his narrow framing of the problem, yet an undeniable catastrophe once we grasp its implications for the planet and future of humanity – at least 3-3.4°C of warming by 2100 (and likely more) (Spratt & Dunlop, 2017). While we can and should critique Victor's disregard for considerations of climate justice (as evinced also by his colleague and sometimes co-author Robert Keohane[55]), even considered on its own terms – creating a framework for climate governance that can prevent runaway climate change and sustain the earth system conditions of possibility for a continuously growing global economy – his approach can only be considered a failure. At the very least, it is an inadequate form of incrementalism that fails to map out how its proposed solution – a piecemeal, fragmentary, and cumulative architecture of bilateral and multilateral agreements based primarily on market-led solutions – could possibly slow down, let alone reverse, global warming and earth system destabilization. As he himself admits: "even a realistic crash program to cut emissions will blow through 2 degrees; 1.5 degrees is ridiculous" (Victor 2015). While the forthrightness here is admirable, especially given that other liberals have yet to grasp (or admit) the fact that the 1.5-2°C target is almost certainly impossible within capitalist constraints, it is unclear then how Victor's approach could lead to anything other than climate catastrophe, mass starvation, hundreds of millions of climate refugees, possible human extinction, etc.

It is useful to engage with Victor's approach to illustrate the problems with liberal continuationist framings of climate change. Thankfully, other approaches in the field of GEP provide broader and more nuanced understandings of the problematic of planetary crisis and the solutions needed to ensure human survival and at least some degree of

[55] As he reportedly states, discussions of justice are "either irrelevant or dangerous in a post-paris world" (quoted in Dooley et al, 2018: 2).

climate justice. Frank Biermann, for example, develops a more comprehensive and (relatively) radical approach to planetary crisis and the possibilities for new forms of Anthropocene governance. Biermann is one of the directors of the “Earth System Governance Project”, which studies

> the sum of the formal and informal rule systems and actor networks at all levels of human society that are set up to steer societies toward preventing, mitigating, and adapting to environmental change and earth system transformation (Biermann, 2014: 9).

For Biermann, this project encompasses both empirical and normative ambitions, in the sense that it investigates the emerging architecture of global environmental governance while also prescribing institutional reforms deemed necessary to navigate towards earth system stability (ibid: 27). Biermann calls his project a “realistic utopianism”, in the sense that it envisions radical yet plausible global institutional transformations that would be needed to ward off a planetary state-shift (ibid). Some of his specific proposals for reformed global governance include transforming the United Nations by upgrading environmental agencies, creating a high-level UN Sustainable Development Council capable of strengthening the coordination between environmental and economic institutions, mainstreaming environmental goals into global trade and financial regimes, and empowering citizens to hold governments and inter-governmental organizations accountable through new forms of representation (e.g. through deliberative global citizens’ assemblies) (ibid: 67, 74, 133; Biermann et al, 2012). The key challenges, for Biermann, will be to create a multilevel governance architecture that can cope with and adapt to environmental uncertainty, protect future generations, balance between the competing dictates of global coordination and national autonomy, address unequal impacts, and promote international solidarity (Biermann, 2014: 40-43).

Biermann's proposals at the very least constitute useful steps in the right direction for understanding the challenges posed by the earth system crisis and envisioning new forms of global governance that are adequate to them. However, it remains beset by isolationist, incrementalist, and continuationist tendencies, since he focuses solely on the earth system crisis, doesn't articulate how his proposals would be capable of achieving their stated aims of ensuring earth system stability, and doesn't consider the potential for structural discontinuities in the liberal-capitalist world order (whether voluntarily through emergency mitigation and adaptation or involuntarily through climate-induced "collapse"). Focusing only on the earth system crisis is understandable for a theorist engaged with the problem of governing the Anthropocene, but given the preeminence of political-economy in configuring our planetary metabolism it seems problematic that these concerns are given such short thrift. Perhaps more importantly, we should ask whether Biermann's proposals, for all their vision and detail, are really adequate to the task of preventing transgression of planetary boundaries. For one, none of these proposals address the roots of the present crisis by advocating a regulatory overhaul of the global economy (let alone a shift beyond capitalism and economic growth). Instead Biermann simply notes that economic and environmental agencies must be more fully integrated to institutionalize "sustainable development", though there is no extended consideration of what the latter actually means, what form it could take in practice, and to what it extent it would be compatible with a continuously expanding capitalist economy. Overall, Biermann's approach is unable to follow through on the objectives it sets out for itself (to envision governance reforms that can "steer societies toward preventing, mitigating, and adapting to environmental change" (ibid: 9)), since it fails to interrogate the structure of political-economic power at the root of planetary crisis or propose governance reforms that would effectively reconfigure this structure and redistribute political-economic power.

The work of Thomas Princen goes significantly further in this regard, which begins to articulate a more radical vision of what genuine sustainability and "ecological order" truly entails (Princen, 2010). Princen recognizes, unlike the vast majority of IR, that the intersecting challenges of climate change, resource depletion, and economic crisis means that "continuationism" is not a viable theoretical or practical response. He writes:

> Proponents of the old normal have a hard time imagining that the twentieth-century economy might not be able to solve critical material problems, that markets and technologies will not rise to the occasion, that clever people with lots of resources and information and very sophisticated modeling cannot deal with disappearing ice packs, pest outbreaks, the end of cheap oil, let alone 'old problems' like poverty, disease, and hunger. For these new problems, *fundamental shifts* are in order to match the fundamentals of the *new normal* (Princen, 2010: 9).

Whereas most continue to believe that the basic strategy of "more-of-the-same-only-greener-and-more-efficient" would be capable of resolving contemporary challenges and underwriting a stable and continuously expanding global economy (ibid: 13-14), Princen shows that the capitalist growth engine is itself built on wispy foundations: not only abundant resources and a stable climate, but more fundamentally "confidence", which is likely to erode as the crises of energy and climate intensify (ibid: 22). Thus rather than continuing on this path towards inevitable "collapse" (ibid: 52), Princen argues that it is time to build a new economy from the ground up, one based on sufficiency, consumer sacrifice, and ecological consciousness.

Princen, more than the other approaches surveyed, has a clearer grasp of the solution-space that emerges from a synthetic and multi-dimensional analysis of our 21st century predicament (as I'll elaborate further in chapter six), which will likely be one that is more localized and has a much lower material-energy throughput (whether through voluntary or involuntary means). His work is thus vital in taking IR beyond its continuationist biases, though he only provides voluntarist and ethical (rather than systemic) solutions. While Princen is a "realist" in that he understands the very real constraints that determine the solution-space for any future economy and world-system, he remains at the level of describing broad principles: "what's needed is some appropriate language and a few good principles to help repel the beast and guide that new construction" (ibid: 37). However, this doesn't begin to consider the sort of political-economic and global governance architectures that might be capable of realizing such principles. Many would also critique Princen for ignoring potential technological innovations in the near-term horizon that may at least attenuate the entwined crises of capitalism, the earth system, and resource depletion. While I agree with Princen that we must not put our faith in such technologies, which will create catastrophic risks of their own (as discussed in the previous chapter), to demonstrate why requires a more multi-dimensional analysis of the planetary problematic as a whole, rather than engaging with the environmental-economic-energy crisis in isolation from these technological trends.

The analyses of Victor, Biermann, and Princen all represent prominent engagements with the problematic of climate change and the Anthropocene from different positions of radicalism: Victor from a position that more-or-less supports the political-economic status quo, Biermann from one that calls for more radical global governance reforms but without transforming the structure of the global political-economy, and Princen from one that calls for a deeper transformation. Yet they all exhibit certain tendencies that limit their capacity to map the planetary problematic and its solution-space. Overall, despite its diversity, the limits of GEP can be roughly understood as a result of tendencies to look at environmental crisis in isolation from other dimensions of the Planetary Problematic, to give limited attention to the concerns of critical political economy, and to provide no systematic framework for understanding how the earth system crisis in conjunction with other dimensions of the planetary problematic will transform world order over the coming decades.[56] As a result, though GEP scholars often understand the deep transformations that planetary upheaval will likely force upon world politics during this century (Nicholson & Jinnah, 2016),[57] their isolationist tendencies prevent them from developing the sort of synthetic analysis we need to grapple with the multi-dimensional complexity of the planetary crisis convergence.

Environmental Security

[56] One approach that to some extent moves beyond these limitations is that of Newell & Paterson (2010), which provides an excellent overview of current trends in capitalist climate governance and possible trajectories moving forward. They to some extent move beyond isolationist analysis by understanding how economic stagnation could hinder climate action (ibid: 166, 179). However, they do not provide of an systematic analysis of the crisis that global capitalism faces as a result of intersecting trends of stagnation, earth system crisis, and net energy decline, and thus provide unrealistic accounts of viable models of "climate capitalism" while downplaying the need for post-capitalist transformation (ibid: x). The work of Peter Dauvergne also provides a deeper political-economic analysis of the drivers of earth system destabilization, illuminating the structural mechanisms and feedbacks through which wasteful production and consumption are reinforced, and also showing how much of the environmental movement has been coopted by this trajectory (Dauvergne, 2016, 2018). Like Princen, he recognizes that societies "will need to reorganize; [and] economies will need fundamental overhauls" (Dauvergne, 2016: 1). However, the solutions he proposes don't go beyond advocating "multiscale and multilayered governance" to constrain transnational corporate power (Dauvergne, 2018: 112), which tells us little regarding the "fundamental overhauls" needed or how they might be actualized.

[57] For example, Daniel Deudney and Elizabeth Mendenhall recognize the real possibility of global systems collapse and the need for a "comprehensively remade world" (Deudney & Mendenhall, 2016: 60, 63-64). But it remains isolationist, ignoring the structural crisis of capitalism and the constraints this imposes on market-led efforts to address environmental crisis, is too sanguine regarding the possibility of shifting capitalism into an ecologically sustainable configuration (for reasons discussed in chapter one), and uses excessively broad brush strokes in painting an "emergent ecological civilization" that ignores deep antagonisms between its various elements (from liberal environmentalist elements on one side to eco-socialist, indigenous, eco-anarchist, and other more radical approaches on the other).

The subfield of Environmental Security is a close cousin to GEP, though its focus lies more within the realms of national and human security discourses rather than global environmental governance. It has its roots in novel approaches to security in the 1970s and 80s that tried to prioritize environmental concerns over traditional national security threats, and since then it has broadened to encompass a variety of concerns. This includes approaches focusing on the links between environmental degradation and conflict (Homer-Dixon, 1999; Selby, 2014; Busby, 2008), Copenhagen School-inspired approaches looking at how "the environment" has been "securitized" in various policy contexts (Trombetta, 2012; Oels, 2012), Foucauldian approaches mapping the emergence of new governmental rationalities that frame hegemonic responses to environmental change (Cooper & Walker, 2010; Duffield, 2011; Evans & Reid, 2014), and human security approaches that focus on the impact of climate change and other environmental transformations on the well-being of communities in various contexts (Barnett, 2002; Sygna et al, 2014; Scheffran & Brauch, 2012; Dalby, 2002, 2009). In this section I will focus primarily on this last set of approaches, since they are more concerned with developing a comprehensive understanding of the causal drivers and human security implications of earth system crisis, while developing potential solutions.

The array of human security approaches to environmental security can be seen as a relatively clear case of agglomerationism: they often exhibit an impressive command of the multiple dimensions of the planetary crisis, providing useful syntheses of information from ecology and the earth system sciences, social scientific investigation of local impacts and adaptation efforts, and research on the implications of environmental change for global food security, energy security, and public health (Barnett, 2002; Dalby, 2009;

Brauch et al, 2011). However, the main problem with these approaches, reflecting the limits of GEP, is that they don't provide a framework that would enable them to systematically map the reciprocally determining dimensions of the planetary crisis – from earth system destabilization to the crisis of capitalism, the sub-crises of energy and food, and new forms of state and non-state violence – which is needed to understand how these crises may unfold and how we may best respond. For one, while environmental security theorists clearly recognize the need to identify the "root causes" driving environmental degradation and human insecurity on a planetary scale (Barnett, 2002: 129; O'Brien et al, 2013: 2), it is striking how relatively minimal effort has yet gone into theorizing the global structures of political-economic power fueling these processes – primarily those of an entropically growth-driven capitalist world-system that is currently consumed by the problem of resolving its *own* internal crisis (Biel, 2012). In this way, as in GEP, they exhibit a disciplinary orientation that tends to relegate political economy to a separate problematic, even though the latter is *fundamentally* a matter of ecological transformation (Moore, 2015). Without attempting a systematic synthesis of these key dimensions of the contemporary field of converging crises, we are left with an impressive yet messy agglomeration of insights regarding the separate dimensions of the problematic without systematically grasping their reciprocal determination and the constraints these impose on the global solution-space. To put it more bluntly, we are given minimal illumination of the mess we find ourselves in, or the catastrophic discontinuity sending the international system into a radically altered state, and how communities, states, regions, and humanity as a whole might navigate its turbulence.

For example, Karen O'Brien and colleagues in their survey of human security approaches to environmental change recognize that we are approaching a "convergence of global crises" and "the end of the world as we know it" (O'Brien et al, 2013: 1). However, they don't provide a systemic mapping of these global systems and crises that would enable us to really understand what this means – what "world" is ending, why, and what might emerge in its wake? They claim that it is necessary to identity with the "root causes" of multiple interrelated threats, writing that this requires "engaging directly with the systems, structures and development paradigms that perpetuate insecurities" (ibid: 2). Yet, strangely, the dominant hegemonic order constraining solutions to the present crisis – neoliberal capitalism – goes unmentioned, and there is no explicit attempt to illuminate what these "systems" and "structures" actually are and how they function. Jon Barnett and colleagues similarly provide useful overviews of the dimensions of environmental security, though they provide little analysis of the specific global political-economic conditions fueling these phenomena. They claim that environmental security is "a function of many social processes that cause some people to be more sensitive and less able to prepare for and respond to sudden and incremental environmental changes" (Barnett et al, 2009: 17), though they don't tell us what these social processes are or how they are systematically interwoven, and the implication seems to be that we're simply dealing with a mess of local phenomena without any sort of emergent global structures and patterns at work.

The collaborative work of Hans Gunter Brauch with Simon Dalby and Ursula Oswald Spring provides a more productive framework for integrating these dimensions that they call "political geoecology", which emphasizes the entwinement of the political dimensions of knowledge and action, the spatial contextualization of this knowledge, and the broader earth system processes to which they respond (Brauch et al, 2011: 1475). They show how most approaches in earth system science and environmental change ignore the political dimension of these processes, and they at least partially foreground the big picture drivers of the present earth system crisis, writing that "the nature of the threat for the survival of humankind is changing from 'them'…to 'us', i.e. to our lifestyle and consumption of fossil sources of energy" (ibid). This approach focuses attention on consumption while obscuring the broader global economic parameters that fuel this consumption, and it doesn't address how the actual configuration of the key dimensions of earth system change constrains the possibility space of global political-economic evolution. Therefore it provides only limited illumination of the kind of systemic transformations that would be needed to resolve the current crisis in an equitable manner. Instead, they focus on the need for policies like "[b]uilding schools with proper seismic structures in earthquake zones, ensuring bridges are big enough to survive large floods and ensuring that pipelines don't rupture in extreme weather" (ibid: 1484). Such policies are of course necessary, but this focus ignores the larger systemic context constraining such policies, and which form the really big fish that any critical political geoecology must fry.

Simon Dalby in his solo work, however, goes furthest towards a deeper analysis of the planetary problematic by more clearly foregrounding the role of political-economic structures in fueling environmental insecurities, their uneven impacts, and their constraints on adaptative/transformative capacities. While his work primarily targets the spatial geopolitical imaginaries that dominate mainstream IR, showing how they're made obsolete by a deeper understanding of ecology and metabolic flows, he also illustrates how dominant framings of and approaches to the current environmental crisis remain wedded to a market logic that aims to secure the conditions of global capitalist reproduction at the expense of the earth system. Dalby therefore makes it clear that "long-term security now means finding ways to change that economy rapidly" (ibid: 440), rather than enacting gradual market reforms that are more concerned with the stability of the hegemonic capitalist order than with the earth system crisis facing humanity.

Dalby's work in this way goes well beyond the limits of other human security approaches to the planetary problematic, illuminating the intersections between the earth system crisis and the problematic of capitalist reproduction and thereby taking us deeper into the "root causes" of the contemporary crisis of socioecological reproduction. However, we can and should go a couple steps further by developing a global systems framework that can more precisely map the global and local parameters that determine the possibility space of world political transformation in the 21st century, shaped primarily by the reciprocal determination between the earth system and capitalist global economy, the key subsystems of food and energy, and processes of technological change. Dalby, like many of the other environmental security theorists, remains an agglomerationist in that he demonstrates deep knowledge of the various dimensions of environmental (in)security, from climate change and adaptation to food and energy security. Yet he doesn't provide a systematic analysis that would enable us to more precisely understand and anticipate the imminent transformations of the entwined international and earth system and formulate plausible solutions. For example, while

Dalby usefully broadens the problem/solution-space beyond the narrow confines of traditional IR concerns to highlight the importance of infrastructure planning, building codes, energy consumption, investments patterns and the like (Dalby, 2009: 155), he does not link these changes to the kind of global political-economic transformation that would be needed to realize them on the scale and with the speed needed. Furthermore, like the environmental security literature more broadly, Dalby leaves out an analysis of the crises of capitalism, energy depletion, and their intersections with the earth system crisis and sets important constraints on efforts to resolve the latter.

In contrast, I argue that these crises must be understood as *intertwined dimensions of a single problematic*, rather than separate problems to be treated by separate disciplines; otherwise we miss the full complexity of the challenges ahead and risk merely shifting problems around (e.g. mitigating climate change while exacerbating economic insecurity for the many, or stimulating global economic growth while dooming the earth system) rather than grasping their mutual entanglement.[58] Thus the field of environmental security remains theoretically limited, devoid of a synthetic and multi-dimensional framework of analysis that could map and orient a collective response to the planetary crisis convergence.

Foucauldian Critical Security Studies

It is worth briefly engaging with another approach within the subfield of Critical Security Studies (CSS), since it is (somewhat paradoxically, given its anti-realist

[58] Leichenko et al come close to articulating the intrication of financial crises and environmental change through their concept of "double exposure", showing how the global economy increases vulnerability among many communities to climate-related risks while constraining their adaptive capacities (Leichenko et al, 2013). However, there is little consideration in their work how processes of economic crisis and environmental change are structurally entwined, rather than merely separate processes that both impinge on human security.

proclivities) *more* attuned to the condition of complex intersecting crises that mark the contemporary planetary condition. However, following Foucault's genealogical method, their approach investigates the discourses and practices through which hegemonic security, development, and other governance agencies frame and respond to contemporary global challenges, rather than trying to understand the implications of these challenges on their own (materialist) terms. The core commitment uniting Foucauldian security theorists is the use of Foucault's genealogical method, which Foucault describes as a mode of historical-philosophical inquiry that aims to identify the "accidents, the minute deviations…the errors…the faulty calculations that gave birth to those things that continue to exist and have value for us" (Foucault, 2010: 81). In particular, Foucauldian scholars are interested in history and present of what Foucault calls "governmentality", which refers to assemblages of discourse and practice, or "power-knowledge" configurations, that relate particular conceptions of the function of government, knowledge about the objects to be governed, and techniques for manipulating such objects in order to attain particular ends (Lemke, 2011: 19-20). Foucauldian inspired CSS scholars investigate how the problem of governance has been problematized by various thinkers and hegemonic agencies in different contexts, and how these problematizations change in response to historical events.

For our purposes, it is worth focusing on how Foucauldians have understood emerging discourses of security and resilience in recent decades. On one hand, many Foucauldians map the emergence of a strategic configuration often associated with the related doctrines of "full spectrum dominance" and "preemption", where US security agencies and their allies aim to master the global security landscape through networked apparatuses of surveillance and force mobilization to detect and preempt threats before they emerge. Brad Evans summarizes this configuration in five core principles: 1) nothing and nowhere is strategically marginal; 2) It is the radically singular which has the capacity to inflict the most damage; 3) success require pre-emptive action; 4) total security is impossible, further attacks inevitable, therefore "unending emergency becomes the norm", and 5) all conventional referents (human/non-human, natural/artificial, internal/external) blur into a "zone of indistinction" (Evans, 2013: 15-16).

On the other hand, the events of Hurricane Katrina and increasing recognition of the threats posed by climate change have led to a new problematization of security signified by the discourse of "resilience", defined by systems ecologist "Buzz" Holling as "a measure of the ability of…systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling, 1973: 17). Unlike what is seen as the increasingly outdated language of "security", which aims to defend a given territory from a limited range of relatively well-defined threats, resilience is being touted as a way to live with uncertainty and absorb the inevitable stresses and shocks that occur in an unstable world without losing system functionality. Jeremy Walker and Melinda Cooper show how this discourse converges smoothly with modes of neoliberal governance that accept and embrace the inevitably of crisis, teaching communities to use it as opportunities for renewal while financial traders profit by anticipating extreme shifts in market value (Cooper & Walker, 2011: 154). The World Banks, for example, now proclaims its strategy as one of "climate resilient growth" that aims to build capacity in developing countries by integrating them into global markets, and in this way appropriates the discourse of resilience to promote existing agendas emphasizing growth and productivity as key strategies for adaptation (World Bank, 2012). The emerging discourse of resilience can in this way be understood to signal a convergence between a hegemonic neoliberal ethos of state non-intervention and the cultivation of entrepreneurial subjects capable of living with and profiting from contingency, and a growing recognition of the limits of government capacity to protect populations in a rapidly changing and increasingly insecure environment (Chandler, 2014).

Perhaps more insidiously, Mark Duffield shows how resilience thinking has become part and parcel of an emerging strategy of what he calls "bunkerization" in which elite spaces are heavily securitized from an increasingly chaotic world, who then orchestrate strategies of "resilience-building" for those left outside. As he describes:

> Bunkers comprise strongholds or defended zones that…have spatially demarcated inside-outside boundaries and defended portals. In a neoliberal world, where life is speculatively abandoned to uncertainty and governed through varying forms of exceptionalism, bunkers provide sites of private consumption and protection for political, economic and cultural elites…Indeed, the bunker has emerged as the architectural response to the abandonment of the political (Duffield, 2011: 19).

Ranging from gated-communities to private shopping malls, central business districts, military green zones, and emerging resilient cities (including future designs for floating cities), bunkers have emerged in growing recognition of accelerating conditions of environmental crisis, offering essential life-support services to elites capable of affording them and thus enabling them to extricate themselves from the public sphere (Duffield, 2011: 21). As seen in certain militaristic prognostications of the emerging threats of climate change, a bunker mentality can be seen to pervade the territorial security thinking of certain military strategists who seek to secure the "core" from the "non-integrated gap" where insecurities often originate (Barnett, 2005). While the rhetoric of political leaders tends to frame climate change as a collective challenge requiring international cooperation on an unprecedented scale, policies more often reflect a bunker strategy in which states strive to develop energy independence while strengthening border security to keep out flows of environmental refugees.

Duffield's analysis of the emerging "bunker" geography of securitization shows how strategies of speculative preemption and resilience-building go hand in hand, with practices of hyper-securitization enabled by US military might in conjunction with vast data-collection apparatuses and predictive algorithms serving primarily to securitize elite spaces of capital accumulation, while strategies of resilience-building serve primarily to aid surplus populations in survival strategies while ignoring the systemic factors driving such inequalities and insecurities. While these strategies overlap in more complex ways than this simplistic geography suggests, it at least helps us make sense of the big picture in emerging patterns of security and insecurity in a world of accelerating crisis conditions. In this brave new world of threat, described by the US Joint Chiefs of staff as "characterized by a rapid rate of change and complexity" (U.S. Department of Defense, 2014: 6), speculative preemption and resilience, along with their underlying complexity onto-epistemology, signal an emergent power-knowledge configuration of emergency governance through which the hegemonic neoliberal military order hopes to maintain resilience, or the "topological cohesion" of its basic system parameters, throughout the turbulence of the 21st century (Cooper, 2011).

Foucauldian approaches in this way provide many useful insights for understanding a critical dimension of the Planetary Problematic – that is, how it is being framed and responded to by hegemonic agencies in the realms of security, development, and economic governance. They show us how emerging forms of knowledge (resilience ecology, complexity theory, futurology), governmental technologies (biometrics, predictive algorithms, insurance, risk assessment), and modes of subjectification ("if you see something, say something!"; "crises are inevitable, cultivate resilience!"; "we [the state] know best how to secure you!") emerging in response to contemporary security challenges are coalescing in heterogeneous yet consistent assemblages of governmentality to sustain the US-led neoliberal order through insecure times. While cosmopolitans often hope that recognition of shared vulnerabilities will lead to the adoption of more inclusive human security agendas, the Foucauldians demonstrate how recognition of the emerging threat landscape is on the contrary generating paranoid practices of hyper-securitization, neoliberal resilience building, and processes of "bunkerization" for global elites worldwide.

To critique Foucauldians for "discourse-centrism" is in one sense unfair, since this is simply the focus of their approach. Indeed I believe it is able to generate productive insights regarding the nature of emerging forms of global governmentality aiming to manage planetary crisis and secure the neoliberal world order. However, the problem is when Foucauldians appear not simply to bracket but also to question the "reality of problems" requiring collective responses. This stance often leaves Foucauldians in the position of merely reacting against dominant articulations of problems rather than honing the art of *autonomously posing problems* (Deleuze, 2004). This is seen in critiques that describe contemporary problematizations of security from a hegemonic perspective, ignore the fact that there may be "truth"[59] in the way these problems are posed, and conclude that we must simply "resist" these articulations. While they describe in often illuminating detail how security agencies problematize emerging environmental threats from climate change (Evans & Reid, 2014), biosecurity threats from emerging diseases and bio-technological weaponization (Collier & Lakoff, 2009; Cooper, 2008), and networked critical infrastructures threatened with cascading failures (Walker & Cooper, 2011; Lundborg & Vaughan-Williams, 2011), among others, rarely do these theorists consider how we might pose such problems differently. Rather, they often appear to assume that accepting their reality is to subject us in advance to the hegemonic agencies seemingly most capable of "protecting" us.

This reactive mode of critique also becomes problematic when it leads Foucauldians to reject frameworks like complexity theory and resilience due to their association with certain forms of neoliberal and security governance. For example, Cooper and Walker are concerned that complexity theory converges smoothly with a neoliberal rationality that entails the integration of ecology and all other concerns within a market-based cosmology of self-organizing systems, which subjects the biosphere to a profit calculus and disables any possibility of immanent critique. Therefore they tell us that these hegemonic practices "cannot be challenged from within the terms of complex systems theory but must be contested, if at all, on completely different terms, by a movement of thought that is truly counter-systemic" (Cooper & Walker, 2011: 157). This both ignores the fact that such practices *are* in fact regularly challenged by scholars deploying the tools of complexity theory (e.g. Srnicek & Williams, 2015; Williams,

[59] "Truth" understood here in a realist though pragmatist sense of *orienting practice to an actually existing material reality* in a way that enables successful interventions into and manipulations of that reality (Negarestani, 2014).

2017; Biel, 2012; Henfrey & Penha-Lopes, 2017; Angus, 2016), as well as the fact that these tools are vital appendages to human cognition in an era of planetary scale challenges defined by emergent processes of self-organizaton, nonlinearity, and complex feedbacks between multiple crises human and non-human systems. David Chandler also argues that these complexity ontologies converge with neoliberal modes of governmentality, though he claims that this due less to the market-based governance it supports than the "post-political" landscape it projects in which the world's complexity exceeds all efforts at human intervention and control, requiring the constitution of a "humble subject" resigned to micropolitical cultivation (Chandler, 2014: 182-184). He is right that there are tendencies towards this usage of complexity ontology, though he ignores a wealth of approaches that deploy these paradigms for explicitly transformative ends (Corry, 2014; Srnicek & Williams, 2015; Burkett & Foster, 2006; Biel, 2012).

Foucauldian approaches are also similarly suspicious of the language of "resilience", since it apparently forces us to accept "the necessity of adaptation to the 'realities' of an endemic condition of global insecurity" (Chandler & Reid, 2016: 2). However, this not only ignores the transformative potential of (certain forms of) resilience thinking and the ways it has been affirmatively articulated by grassroots transition movements (Hopkins, 2008; Henfrey & Penha-Lopes, 2017) but also simply ignores the practical necessity of cultivating something like "resilience" given the reality of our planetary predicament. Given the crises outlined in the previous chapter, individuals and communities have no choice but to cultivate the resilience needed to navigate the turbulence ahead, which does not by any means require foregoing the powers of resistance and transformation (as many Foucauldians believe) (Evans & Reid, 2014; Chandler, 2014). Instead, as many transition activists emphasize (Henfrey & Penha-Lopes, 2017), genuine resilience can *only* emerge through resistance to and transformation of the current neoliberal capitalist world order, since many of the principles it emphasizes (e.g. relocalization, modularity, redundancy, communal solidarity, and steady-state economics) are literally the “antithesis of the systems and practices that underpin our current globalized economy” (Ahmed et al, 2015: 105; see also Lewis & Conaty, 2012).

Overall, the main problem with the Foucauldian critique is that it merely reacts to certain (superficial) deployments of complexity theory and resilience by hegemonic agencies, rather than engaging the Planetary Problematic on its own terms and wielding the theoretical tools most capable of developing counter-hegemonic mappings and responses. But it is still valuable to engage with these analyses, both for understanding how the Planetary Problematic is being framed and managed by hegemonic agencies, as well for providing a way of conceptualizing hegemonic solutions to dimensions of this problematic (which I will later call “security assemblages”). Though their approach is discourse-centric, it can be integrated with a broader “realist” approach to systemically mapping the planetary crisis convergence and informing local and global praxes for actualizing more just and sustainable futures. In this sense, my intent is not to dismiss the importance of hegemonic discourse analysis in understanding the Planetary Problematic, but rather to see this as an important tool for understanding the role of power in constraining the space of possible futures, which must be challenged by counter-hegemonic praxes from below aiming to articulate the planetary problematic and solution-space in the interests of human and non-human life (an “affirmative biopolitics”, as some Foucauldians might put it, though I find the term a bit limiting; an affirmative "bio-geo-eco-techno-neuro politics" is closer to the times calls for).

Conclusion: Planetary Politics Beyond IR

All of the approaches just surveyed provide useful insights that bring us closer towards an articulation of the Planetary Problematic. It is not my intention to dismiss their value, simply to indicate their limits in formulating the multi-dimensional and systematic analysis we need to map, anticipate, and navigate the planetary crisis convergence. I argue that the kind of approach we need is one based on a complex systems ontology that integrates biophysical and political-economic parameters at multiple scales; enables us to see the relations and feedbacks between diverse problem-domains; integrates the latest scientific insights regarding the processes of earth system destabilization, resource depletion, and technological change; and helps us to formulate systemic responses that are can address these crises simultaneously in ways that promote global environmental and economic justice.

As noted in the introduction, various theorists across the field of IR, especially those drawing from complexity theory, have begun to move in this direction. Antoine Bousquet lucidly articulates the need for a complex system ontology that integrates the biosphere and technosphere as fundamental constituents of world politics (Bousquet, 2015; Bousquet & Curtis, 2011). The co-authored work of Stephen Hobden and Erika Cudworth moves in this direction as well, formulating a "posthuman" complex systems that embeds the international system in its encompassing non-human milieu (Cudworth & Hobden, 2011). Emilian Kavalski notes that many of the complex challenges of our time

– from financial crises to energy depletion, climate change, and pandemics – exhibit turbulent dynamics and sharp discontinuities that cannot be understood through dominant IR methodologies (Deudney, 2018), and instead require a shift in the direction of complexity (Kavalski, 2015: 2). Political theorist William Connolly has also been at the cutting edge of such efforts, and his work challenges scholars to move beyond both "sociocentrism" – the tendency to focus solely on social or political-economic dynamics – and "gradualism" – the tendency to assume gradual and linear processes of change at the expense of radical discontinuities (Connolly, 2011, 2017). Furthermore, the "Planet Politics" manifesto, co-authored by Anthony Burke, Simon Dalby, Audra Mitchell, Stefanie Fishel, and Daniel Levine, provides a powerful statement regarding the epochal implications of climate change for both the theory and practice of IR. In their words:

> our paradigms fail the real. International Relations, as both a system of knowledge and institutional practice, is undone by the reality of the planet…there needs to be an isomorphism between the planetary scale on which Earth System Science is producing knowledge about the earth, between the planetary scale of actual and potential extinctions, and between an ethical, moral, ontological and practical discourse that might be adequate to them (Burke et al, 2016: 3, 8).

Burke and colleagues go on to state that this requires "the recovery of an earlier notion of IR as an interdiscipline comprised of multiple research programmes, intellectual traditions, and normative perspectives – this time with the Anthropocene as its spur to innovation" (ibid). This is a productive articulation of the kind of approach needed to understand the planetary crisis convergence, though Burke et al only focus on the dimension of climate change – ignoring its intersections with the crises of capitalism, energy, and new technologies of violence – and thereby remain isolationist. Overall, while these approaches all provide useful conceptual mappings of world politics that move beyond the limits of mainstream approaches, they do not provide a multi-dimensional analysis of the contemporary planetary crisis convergence and its possible trajectories. While they recognize the need to integrate biophysical parameters,[60] map feedbacks between human and non-human processes at multiple scales, and account for non-linear changes catalyzed by "tipping points", they have not applied these insights towards an analysis of planetary crisis that can clearly perceive, analyze, and help us navigate the imminent catastrophic discontinuity that is set to transform world politics.

Two relative exceptions to this tendency include the work of Daniel Deudney (which I will discuss in more depth in the following chapter) and Thomas Homer-Dixon. Homer-Dixon probably goes furthest among IR theorists in using the tools of complexity to develop a synthetic and multi-dimensional analysis of our planetary predicament, which goes beyond climate change to integrate numerous other dimensions. Homer-Dixon clearly recognizes and warns of the potential for a global systems breakdown driven by the accumulation of social, economic, and environmental risks (Homer-Dixon, 2006: 17-18). In particular, he foregrounds five "tectonic stress", including population growth, growing energy scarcity, environmental degradation, climate change, and economic instability, which collectively form "concatenating problems" that mutually amplify each other in unexpected ways (ibid: 11, 223). While his book catalogues these problems in relative isolation from each other, he emphasizes that the dense intersections between political-economic, technological, and ecological systems on a global scale raises the potential for "synchronous failure", or a cascading process of system breakdown in which local shocks reverberate across a network of social, ecological, and technological relations (ibid: 16). In his words:

[60] Though none of them, somewhat oddly, integrates an analysis of energy depletion.

> a society is more likely to experience breakdown when it's hit by many severe stresses simultaneously, when these stresses combine in ways that magnify their synergistic impact…and when this impact propagates rapidly through a large number of links among people, groups, organizations, and technologies…If our societies arc already brittle because assimilating stresses have eroded their resilience over time, what starts as a local and seemingly manageable breakdown could jump boundaries and quickly spread around the globe, and might even trigger a collapse of global economic and political order (ibid: 109-110, 127).

Homer-Dixon's analysis here remains a bit speculative and suggestive, more agglomerationist than systematic and synthetic (i.e. a chapter on energy, one on climate change, one on the economy, etc.).[61] It also leaves out a structural analysis of political-economic power, exploitation, and resistance, which leads him to fall short of grasping the post-capitalist transformations needed to respond to the planetary crisis convergence in a genuinely sustainable and just manner (Ahmed, 2010). But his approach effectively captures fundamental aspects of the contemporary world system: the dense connectivity and feedbacks between political-economic, ecological, and technological systems; the growing vulnerabilities posed by earth system destabilization, energy depletion, economic instability, and the growing destructive power of non-state actors; and the likelihood of a catastrophic discontinuity (even "collapse") in the global political economy in the coming decades. The theoretical framework developed in this dissertation will attempt to incorporate these insights in a more encompassing and synthetic framework that can analyze the relations and feedbacks between these crises, map their possible trajectories, and illuminate the role of political-economic power and counter-hegemonic struggle in determining which trajectories will be actualized (and how).

[61] Though his co-authored piece with Marten Scheffer, Johan Rockström, and several other prominent resilience scholars provides an excellent synthetic analysis of the reciprocally determining financial, energy, and food crises in 2007-08 (Homer-Dixon et al, 2015). I will return to this piece in chapter six.

As noted in the introduction, one of the main limits of existing forays into complexity theory and the Planetary Problematic is that they have yet to engage with the Marxist tradition. This is because Marxist approaches provide a more systemic rather than sectoral approach for understanding the planetary crisis, which foregrounds the capitalist drivers of the crisis, the constraints it imposes on efforts to resolve it, and the consequent need to take seriously a post-capitalist solution-space. While many in the field of IR continue to perpetuate a strawman understanding of Historical Materialism and Marxist critique, I will show in the next chapter that many working from within this tradition have gone furthest in understanding the contemporary planetary problematic, especially those who have begun to map the reciprocal determination between the earth system crisis and the structural crisis of global capitalism (Moore, 2015; Foster, 2013; Biel, 2012). Thus to formulate the alternative framework we need, our subsequent necessary step is to engage with Marxist political economy, especially those approaches within it that are most alive to the planetary crisis convergence, while also illustrating its limitations. This will be the task of the next chapter.

Chapter Three: Marxist Analyses of Planetary Crisis (and their limits)

This chapter turns to an engagement with Marxist analyses of the contemporary planetary crisis. As noted in the introduction, Marxism has witnessed a resurgence in the past decade due in large part to the 2007-08 financial crisis and growing concern about the capitalist drivers of climate change. Beyond this, while Marx is commonly accused of having been "proven wrong" that, following the teleological laws of history, communism would ineluctably replace capitalism, it is increasingly recognized that his work was extraordinarily prescient in anticipating the broad contours of 21st century capitalism. This is because many of the inherent tendencies he perceived in the capitalist mode of production have been among the most crucial shapers of the contemporary world: including the globalization of capital and its relentless assault on all non-capitalist forms of economic organization, the continuous revolutionizing of the forces of production and replacement of human labor with machines, the persistence of "primitive accumulation" as a necessary component of capitalist expansion, the tendency towards the centralization of capital in financial and corporate oligopolies, the intensification of inequality between workers and capitalists, the creation of a global "reserve army of labor" to keep wages low, the drive to increase the speed of capital circulation through investments in communication and transportation technologies, the degradation of the soil by capitalist agriculture, and (not least) the continuous lurch from economic crisis to crisis as a result of capitalism's inherent contradictions (Ahmed, 2010; Foster, 2018; Anievas, 2010; Harvey, 2010). This is certainly not to say that Marx got everything right, but merely to illustrate that his framework of analysis, which has been developed in numerous and often antagonistic directions under the umbrella of "Historical Materialism" (HM) remains one of the most productive approaches for understanding the roots of the contemporary planetary crisis and helping us anticipate how it may unfold.

I will begin the chapter by providing a brief overview of some of the key elements of Marxist political economy. The aim here is not to give an exhaustive overview of Marxist theory and debates, but rather to provide a partial reconstruction that is useful for my subsequent analyses. I will then engage with specific Marxist approaches that are most alive to the conjuncture of planetary crisis and the task of formulating counter-hegemonic responses, including Neo-Gramscianism, World-Systems Theory, and Ecological Marxism. After going through these Marxist approaches, the chapter will then conclude with an overview of Daniel Deudney's "Historical Security Materialism", which is a non-Marxist approach to HM that allows us to incorporate a crucial dimension of the Planetary Problematic that is often ignored by Marxist approaches – the entwined problems of security-from-violence and technological change. By understanding both the strengths and limitations of these approaches for developing a synthetic and multi-dimensional analysis of the planetary crisis convergence, we will then be in better position to formulate an alternative approach, but one that is deeply indebted to these analyses.

Marxist Historical Materialism

Given that the converging crises of the 21st century revolve around humanity's metabolic relation to the natural world through its production of the basic needs of life, it should not be surprising that HM has been at the forefront of analyzing these crises, their causal drivers, and possible solutions. For the metabolism between humans and nature – the processes through which humans produce and reproduce themselves through an exchange of matter-energy with their environments – can be said to constitute the core problematic of HM (Foster, 2000; Anievas, 2014: 53). As Marx writes in *Capital Volume 1:*

> The labor process…is purposeful activity aimed at the production of use-values…It is the universal condition for the metabolic interaction between man and nature, the everlasting nature-imposed condition of human existence, and it is therefore independent of every form of that existence, or rather it is common to all forms of society in which human beings live (Marx, 1992: 290).

And again in the *The German Ideology*:

> life involves before everything else eating and drinking, a habitation, clothing and many other things. The first historical act is thus the production of the means to satisfy these needs, the production of material life itself. And indeed this is an historical act, a fundamental condition of all history, which today, as thousands of years ago, must daily and hourly be fulfilled merely in order to sustain human life (Marx, 1978: 148).

In this sense, we can broadly understand HM as an investigation of the social forms through which individual and communal life is produced and reproduced in diverse ecological contexts, with particular focus on the *relations of productions* (the social relationships, whether hierarchical or egalitarian, through which production is organized and surpluses distributed) and the *forces of production* (the material-energetic and technological bases of production). From this starting point follows an analysis of the imbrication of these modes of production with various cultural, political, institutional, and infrastructural configurations; the structural antagonisms or "contradictions" constitutive of these modes; and their corresponding dynamics of crisis and transformation. While Marxism is commonly dismissed as an economic reductionist framework that effaces the complexity of social relations and political dynamics at different scales, it can instead be read as emphasizing how all cultural, political, and institutional configurations (at both national and international scales) are conditioned by and emergent from the processes of production, distribution, and consumption through which social life and its ecological basis are reproduced and transformed. These include the processes through which food is grown and distributed, energy extracted and consumed, raw materials mined and concretized in the built environment, and children raised and households maintained. In the field of IR this has led to the insight that, as Justin Rosenberg explains, "geopolitical systems are not constituted independently of, and cannot be understood in isolation from, the wider structures of the production and reproduction of social life" (Rosenberg, 1994: 6). In this way, Marxist IR claims to investigate the "social totality" through a holistic methodology that doesn't divorce the reproduction of social life from higher order political and international structures, seeing the latter as "emergent" from the former (Anievas, 2010; Joseph, 2010b).[62]

While the metabolism between humans and nature and the relations of political-economic power that structure this metabolism constitutes the transhistorical focus of HM, the primary object of analysis and critique for Marx and Marxists has of course been the capitalist organization of this metabolism. Capital, for Marx, is the process of self-expanding exchange value through which labor-power and fixed capital are brought together to produce commodities that are sold on the market for profit, which are then reinvested in production to generate more profit and so on in an ever-expanding circuit (Marx, 1992: 248). "Capitalism", then, refers to a social formation in which the accumulation of exchange-value (rather than use-value) is hegemonic, or one in which

[62] The nature of this relation between the interstate system and the global capitalist economy is articulated in numerous ways and forms a key axis of debate among Marxist IR scholars, with Immanuel Wallerstein tending towards a functionalist conception of the interstate system as necessary to the reproduction of capitalism (Wallerstein, 1974); Giovanni Arrighi, David Harvey, and Alex Callinicos emphasizing the interpenetration of relatively autonomous "economic" and "territorial" logics of competition (Arrighi, 2010; Harvey, 2003; Callinicos, 2010); Benno Teschke and Hannes Lacher arguing for more historically nuanced rather than structurally determined accounts of the evolving relations between capitalism and the state system (Teschke & Lacher, 2010); and William Robinson arguing for a "transnational" account of global capitalism in which transnational corporations, financial institutions, investors, and value-chains are so globally integrated that it no longer makes sense to think in terms of competing nation-states (Robinson, 2010).

the majority of individuals reproduce themselves via the circuit of capital (i.e. by selling their labor-power and purchasing commodities on the market). A capitalist social formation is characterized by this form of social interdependence whereby individual producers are separated from their means of production, are forced to sell their labor-power in order to earn money to purchase their means of subsistence on the market, and thereby contribute to the self-valorization of capital both as workers and consumers. This process forms, as Moishe Postone explains, "a sort of objective system over and against the individuals, and it increasingly determines the goals and means of human activity" (Postone, 1993: 154). This could be understood as an *emergent* structure[63] in the sense that it arises from lower-level interactions (competition between capitalists and their nation-states) and exerts top-down causation on all lower-level agencies and institutions. In this sense, once capitalist prerogatives become dominant in a nation-state, regional, or transcontinental world system, the pressures of market competition serve to discipline all agencies within its geographical field of action to adopt capitalist motives, while punishing those that don't (e.g. by driving them into hunger, off their land, out of business, into debt, etc.) (Wallerstein, 2004: 24).

One of the keys to Marxian analyses of capitalism is in understanding the system's inherent "contradictions," which can be shifted and temporarily attenuated through "spatiotemporal fixes" without being genuinely resolved (Harvey, 2014: 3-4; Jessop, 2008). These contradictions, which can also be thought of as structural antagonisms or conflicting tendencies, give rise to both *cyclical* patterns of economic

[63] As Roy Bhaskar explains, an emergent structure is one that depends for its existence on the interactions and relations between lower-level entities, though it is causally irreducible to them in the sense that it exerts top-down causal pressures to maintain them within a specific configuration, thereby manifesting properties and behaviors that can't be explained with reference to the lower-level entities alone (Bhaskar, 2016: 32).

crisis and regeneration (or "creative destruction"), as well a *secular* tendency towards dwindling profitability, increasing instability, and environmental degradation in the long-term (Wallerstein, 2004, 2011). For example, the discipline of market competition that differentiates capitalism from earlier economic systems forces capitalists to keep wages low to maximize the rate of profit, though they also require workers to purchase their commodities in order to realize their profits, a contradiction that manifests through periodic "crises of overproduction", and which is temporarily attenuated but not resolved (rather exacerbated) through the spread of credit and debt (Harvey, 2010: 16-17). On a deeper level, capitalism is characterized by a contradiction between use-value and exchange-value, since the system is driven by the tendency to maximize exchange-value (i.e. monetary profit), though its human inhabitants require use-values to sustain and reproduce themselves (primarily food, clean water, housing, healthcare, etc). While the production of use-values and exchange-values often coincide, the dominance of production for profit tends to marginalize social use-values, thus requiring state intervention to supply use-values like public infrastructure, education, and basic healthcare. While these interventions often succeed in displacing or deferring the effects of certain contradictions, either in space (through colonialism or the "superexploitation" of labor in peripheral countries) or time (through debt and environmental degradation), they are unable to genuinely *resolve* the contradictions, which would require moving beyond an economy organized primarily for the accumulation of exchange-value (Jessop, 2008; J. Smith, 2016).

It is as a result of these contradictions that capitalism enters periodic "crises" that force the system to adapt and restructure. Most economists agree that a "healthy" capitalist economy expands at about 3% per year, which builds on itself each year to produce an exponential expansion in the overall scale of production, circulation and consumption. When growth slows or goes in reverse, which can be the result of several potential barriers – including insufficient financial capital, scarcities of (or difficulties with) labor supply, inadequate means of production or "natural resources", or lack of demand in the market – capitalism is said to enter a "crisis" (Harvey, 2010: 47). As William Robinson explains, there are three varieties of potential capitalist crisis. First, and most common, are "cyclical" crises that are mainly the result of the downswing of a normal business cycle and don't require any major restructuring of the system (Robinson, 2010: 302). Second are "structural" crises, in which a specific "accumulation regime" – defined by a configuration of institutional regulations and national and global scales, technological capacities, organizational forms, and dominant industries – is no longer able to sustain growth, thereby forcing organizational, technological, and geographical transformations that enable capital to overcome these limits and continue on a renewed growth trajectory (Harvey, 2010: 71). The 1930s great depression, the 1970s stagflation, and the contemporary crisis of neoliberalism can all be understood as structural crises in this sense. Finally, Robinson raises the possibility of a "systemic" crisis, which could also be called a "terminal" crisis in which the capitalist system is unable to successfully restructure itself in order to resolve a structural crisis, and thereby collapses or transforms into a qualitatively novel form of political-economic organization. He explains:

> A structural crisis opens up the *possibility* for a systemic crisis. But whether it actually snowballs into a systemic crisis…is not predetermined and depends entirely on the response of social and political forces to the crisis and on historical contingencies that are not easy to forecast (Robinson, 2010: 302).

The "solution" to these contradictions and crises, for Marxists, cannot lie within a capitalist system itself, as Keynesians believe, but requires a transition beyond capitalism towards "socialism" (or "ecosocialism"). There is much disagreement among Marxists regarding the nature of socialism (especially regarding the role of the state, markets, and wages)[64], or what it would mean to have decisively broken from capitalism, but they follow the general principle that socialism entails a political-economic system in which production is predominantly organized for the creation of *use-values* (rather than exchange-value), and in which the means of production are collectively rather than privately owned (Hudis, 2014). In such a society, increases in productivity or in the overall scale of production and consumption would be determined by conscious decision-making on the part of human agents rather than being mandated by the pressures of market competition. In this way "growth" would cease to be a systemic imperative but rather an optional trajectory subject to democratic contestation, and it would no longer be measured according to increases in abstract exchange-value (i.e. GDP) but by alternative metrics like material abundance, leisure time, physical and mental health, and environmental sustainability (Postone, 1993: 310). Thus when contemporary economists discuss the need to replace GDP with other measures of human well-being in determining the organization and health of the economy (e.g. WEAll, 2020), they are at least *potentially* outlining the metrical basis of an (eco)-socialist system, though Marxists

[64] As Hudis notes, those who focus on the market as the defining feature of capitalism conclude that the key to transitioning beyond capitalism is to "abolish markets and establish state control of production" (Hudis, 2014: 14). In contrast, those who focus on wage labor emphasize that abolishing the capital-labor relation, or the structural power of capitalists over workers who are forced to sell their labor-power to survive, is the key to transcending capitalism (e.g. Holland, 2011). In my view, the problem is not markets *per se* but the emergent character they take under capitalism, which disciplines all producers and enterprises to adapt capitalist motives or die. In this sense, the goal of a socialist political-economy would not *necessarily* be to abolish markets and money, but rather to reconfigure them by transforming the underlying relations of power and production.

emphasize that this must also entail a transformation in the relations of production that abolishes (or at least significantly curtails) the power of the capitalist class.

While much of Marxist scholarship is primarily theoretical and historical, particularly in IR, many Marxists have deployed their theoretical tools to analyze our current conjuncture of political-economic and planetary crisis. Among those approaches, I will focus here on the sub-fields of Neo-Gramscianism, World-Systems Theory, and Ecological Marxism.

Neo-Gramscianism

Neo-Gramscian IR is often traced back to the work of Robert Cox, though it of course has its roots in the work of Italian Marxist Antonio Gramsci. Gramsci's work is significant within the Marxist canon for developing a philosophical concept of "hegemony" that could grapple with the social complexities that plagued the structural frameworks of classical Marxism.[65] Whereas earlier Marxists assumed that political ideology flowed directly from class positioning, Gramsci gave greater attention to the complex negotiation between different class perspectives and their uneven integration and pacification within a particular system of rule (undergirded by a shared "common sense") (Gramsci, 1971: 364). While many today continue to associate the term hegemony with "consent" (as opposed to "coercion"), and critique it on this basis, Alex Williams emphasizes that it should rather be understood as a complex "equilibrium of

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[65] As Laclau and Mouffe argue, this concept emerged within early 20th century Marxist thought primarily as a response to the historical contingencies that challenged classical Marxist conceptions of the ontological centrality of the working class, the role of (capital R) Revolution as the grounding moment in the transition to another state, and the possibility of a unitary and homogeneous collective will that would render pointless the moment of politics (Laclau & Mouffe, 2001: xxii). They argue that Gramsci's understanding of "complex hegemony" indicates an important break from these earlier tendencies, though it continues to privilege class, namely proletarian hegemony, as the primary horizon of struggle (ibid: 59).

forces" that emerges through the relations and feedbacks between multiple sectors, systems, and agencies, from the economy and state to civil society, culture, and technical infrastructures (Williams, 2017: 5). Hegemony is used in this sense not only as a lens through which to understand the operation of power but also for strategically orienting a counter-hegemonic movement aiming to supplant the dominant hegemony. In this sense, theory for Gramsci, following Marx's theses on Feuerbach, had the aim of mapping a historical conjuncture in order to orient a strategy for constructing proletarian hegemony, which he called the "philosophy of praxis" (Gramsci, 1971: 365l). In Gramsci's words, the ultimate aim of the philosophy of praxis in this sense would be to develop

> a theory which, by coinciding and identifying itself with the decisive elements of the practice itself, can accelerate the historical process that is going on, rendering practice more homogeneous, more coherent, more efficient in all its elements, and thus…developing its potential to the maximum (Gramsci, 1971: 365).

Gramsci's counter-hegemonic philosophy of praxis forms one of the key precursors for Robert Cox's later articulation of "critical theory" (Cox, 1981), and his emphasis on political constituted (rather than structurally determined) hegemonic formations has inspired much of the "cultural turn" in late 20th century Marxism (Laclau & Mouffe, 2001). For the purposes of this dissertation, however, I will focus primarily on the work of Stephen Gill, who has done the most from a Neo-Gramscian perspective to analyze the contemporary crisis conjuncture. Gill follows Gramsci in conceiving the contemporary crisis as an "organic crisis", where the old relations of (neoliberal) hegemony are breaking down and a new hegemony is as yet unable to emerge and assert itself (Gill, 2010). Gill recognizes that "the term 'economic crisis' cannot begin to capture the scale and the depth of what is at issue" (Gill, 2011: 16), which instead must be understood as a condition of

> several intersecting, and ontologically distinct, crises in geopolitics, political economy, law, ethics, culture, society and ecology…[which] call into question the prevailing imperial and neo-liberal models of global capitalist development and global governance (Gill, 2012: 522).

Gill and his collaborators engage in what he calls "critical problem-solving" to analyze the various dimensions of the organic crisis and propose progressive solutions (Gill, 2011: 1). Contributors primarily focus on the crisis of neoliberalism and its generation of a global scale "crisis of social reproduction", in which hegemonic strategies to stabilize the financial-based global economy have resulted in escalating public debt and devastating cuts to social services in many countries, with unemployed workers forced to develop precarious survival strategies outside the market system (Gill & Bakker, 2003). But they have also provided useful analyses of the entwined crisis of public health (Benatar et al, 2011), the climate crisis (Gill, 2011; Falk, 2011), and the incipient dangers of new forms of militarization and securitization to police unrest and secure against "disorder" across the globe (Gill & Bakker, 2003).

Gill rightly argues that we are living through something like an "organic crisis", and his work provides a useful orientation for counter-hegemonic movements aiming to create alternative solutions that supplant the dominant neoliberal common sense. But his work exhibits some of the same agglomerationist tendencies we examined in the previous chapter: the tendency to document numerous challenges without articulating their relations and without systematically analyzing their implications for the present and future of world order. Gill is therefore vulnerable to criticisms that are often made of Neo-Gramscian IR, such as the claim that it is unable to articulate a coherent account of social transformation that matches its progressive agenda (Saurin, 2008), that it elevates questions of ethics without engaging in a systematic or "objective" analysis of the contemporary conjuncture (Joseph, 2008), and that it remains content with proclaiming "solidarity" with counter-hegemonic movements without analyzing the underlying relations of force or proposing organizational or transformational strategies (Gruffyd Jones, 2008). While Gill recognizes that systemic solutions to the entwined dimensions of the contemporary organic crisis, from economic instability to climate change, will require moving beyond both neoliberal and traditional Keynesian strategies (Gill, 2011: 16), he does not provide a multi-dimensional and synthetic analysis that would enable us to anticipate how the planetary crisis convergence may unfold or illuminate the opportunities for transformative agency it may provide.

Nick Srnicek and Alex Williams help to push Neo-Gramscian analysis beyond these limitations by integrating the insights of Complexity Theory. One of their key contributions is the further development of Frederic Jameson's concept of "cognitive mapping" as a means to enhance our cognitive traction on, and capacities to navigate and resolve, complex global challenges. They write: "problems such as global exploitation, planetary climate change, rising surplus populations, and the repeated crises of capitalism are abstract in appearance, complex in structure, and non-localized", which will require "new cognitive maps, political narratives, technological interfaces, economic models, and mechanisms of collective control" to make radical alternatives possible (Srnicek & Williams, 2015: 40, 16). Connected to this epistemic project of mapping global complexity is one of informing counter-hegemonic strategy (following Gramsci's "philosophy of praxis") to challenge and navigate beyond the dominant (neoliberal) common sense. The objective of a counter-hegemonic project, in Srnicek and Williams's terms, is

> to navigate the present technical, economic, social, political and productive hegemonic towards a new point of equilibrium beyond the imposition of wage labor…A hegemonic project therefore implies and responds to society as a complex emergent order, the result of diverse interacting practices (ibid: 136).

Overall, they believe that their approach provides a more rigorous analysis of the current conjuncture that can illuminate utopian potential (in particular a "post-work future") that is immanent to the present (ibid: 139).

Srnicek and Williams's concepts of cognitive mapping and counter-hegemonic strategy are an important inspiration for the theoretical framework developed later in this dissertation. While deeply indebted to their work, my analysis will also break from them in important respects. Most importantly, as other critics have emphasized (Kay, 2015; Grove, 2019), Srnicek and Williams are unable to follow through on their calls for a CT-inspired form of cognitive mapping that can help us understand and navigate global complexity due to their relative neglect and under-estimation of looming ecological constraints. This is made evident by the reliance of their project on the possibility of "limitless clean energy" (ibid: 1), as well as their belief in the "utopian possibility of a globally interconnected system in which parts and goods can be shipped rapidly and efficiently without human labor" (ibid: 182). These claims not only ignore the numerous studies demonstrating the likely limits of renewable energy and its ecological impacts (Heinberg & Fridley, 2016; Moriarty & Honnery, 2016; Capellan-Perez et al, 2019; Mulvaney, 2019; Ahmed, 2018), but also fail to consider how these supposedly "green" technological infrastructures could be constructed without relying on extractivist relations with the global south (who would suffer the toxic consequences) (Kay, 2015; Táíwò, 2019). Further, even *if* such constraints were overcome through technological innovation – which Srnicek and Williams appear to confidently expect (Srnicek & Williams, 2015: 1) – they ignore how advances in nanotechnology, biotechnology, 3d printing, robotics and AI would create new security threats and totalitarian dangers (as discussed in chapter one) that would threaten their utopian postcapitalist future. In short, while Srnicek and Williams provide useful inspiration for thinking about what it would mean to map global complexity in a systematic way that can productively inform counter-hegemonic strategy, they have yet to truly develop the kind of synthetic and multidimensional analysis we need to understand and navigate our planetary conjuncture.

World-Systems Theory

Though often criticized as a reductionist and structurally determinist framework (e.g. Pieterse, 1988), theorists working under the banner of World-Systems Theory (WST) have provided some of the most productive analyses of the contemporary crisis conjuncture. WST investigates the emergent global-scale dynamics of the capitalist world market and its structuring effects on inter-state relations, which include secular tendencies towards market expansion and space-time compression, cyclical crises that impact all regions of the world-system (in geographically uneven ways), hegemonic transitions between leading capitalist powers, and forms of unequal exchange between core and peripheral spaces (Wallerstein, 1974b, 2004; Arrighi & Silver, 1999; Arrighi, 2010; Chase-Dunn & Hall, 1997; Amin, 1990). World-systems are understood as interaction networks composed of multiple polities that are economically integrated via a division of labor, while the *capitalist* world-system is conceived as a world-system in which the accumulation of capital is the hegemonic form of social reproduction – one in which the majority of individuals and communities are dependent on the world market for their daily subsistence.

While traditional Marxist approaches were methodologically nationalist in their understanding of the dynamics of capitalist evolution (e.g. Brenner, 1987), WST emphasizes that the emergence and continuous reproduction of capitalism can only be adequately understood as a world-systemic phenomena in which core, peripheral, and semi-peripheral spaces are integrated by an emergent world market, which creates simultaneous tendencies towards equalization and uneven development.[66] Cores spaces refer to areas where the most profitable and cutting-edge forms of production are located and wages are highest, and peripheries to where profit-rates and wages are lowest (as a result of colonial histories and asymmetries in military-economic power) which results in a net transfer of "value" to the core via cheap exports (Chase-Dunn & Grimes, 1995). Semi-peripheries, meanwhile, are spaces that are less rich and powerful than the core but more autonomous from core domination than the periphery, which makes them potentially a site of social and institutional innovation (since they are both more autonomous and less beholden to older practices and institutions than the core) (Chase-Dunn & Hall, 1997: 46-47). Rather than positing a structurally static core and periphery, we should instead understand this to be a dynamic process in which former peripheries may become cores and former cores may become peripheries (ibid: 3). And rather than

[66] Here I am putting a bit of an "uneven and combined development" spin on world-systems theory (see Rosenberg, 2006; Anievas, 2014; Anievas & Nisancioglu, 2015). Marxist IR scholars like Rosenberg and Anievas, who have done excellent work on uneven and combined development, are right to emphasize the need for a Marxist approach that integrates geopolitical and capitalist dynamics without subsuming the autonomy of states. But these insights are arguably compatible with many of the later articulations of WST, and I believe it is most productive to integrate them within a WST framework to retain the latter's insight into the secular and cyclical dynamics of capitalism and the possibility space of the 21st century crisis.

only focusing on relations between the global north and south, or between nation-states, it should be emphasized that core, peripheral, and semi-peripheral spaces can be seen at all geographical scales – not only between but also within nation-states, regions, and cities – forming a kind of fractal pattern of uneven development (N. Smith, 2008: 6-7).[67]

Most importantly, for our purposes, WST maps the evolution of capitalism in terms of both a long-term trend towards geographical and material-technological expansion as well as a cyclical process in which "long waves of accumulation", each supported by a particular constellation of technologies, organizational forms, and hegemonic powers, emerge and give way to successive formations through periodic crises. Wallerstein maps these long waves as a series of "Kondratieff cycles", which tend to be 50 year cycles in which a specific regime of accumulation catalyzed by a leading set of industries leads to extensive employment, rising profit rates and wages, and a general sense of prosperity, before reaching a point of decline where markets saturate and profit-rates fall. At that point the accumulation regime enters a "structural crisis", often accompanied by depression and war, which can only be resolved through the creation of either a new accumulation regime or an alternative world-system. In Wallerstein's (Complexity Theory-inspired) words:

> True crises are those difficulties that *cannot* be resolved within the framework of the system, but instead can be overcome only be going outside of and beyond the historical system of which the difficulties are a part…what happens is that the system bifurcates…the system is faced with two alternative solutions for its crisis, both of which are intrinsically possible (Wallerstein, 2004: 76).

[67] The geographer Neil Smith makes a useful critique of (certain approaches to) WST by emphasizing the multi-scalar nature of uneven development. He writes: "it is possible to see the uneven development of capitalism as the geographical expression of the more fundamental contradiction between use-value and exchange-value. The pattern which results in the landscape is well known: development at one pole and underdevelopment at the other. This takes place at a number of spatial scales. Dependency theory, center-periphery theory, and the various theories of underdevelopment all capture something of this process. But their focus tends to be on the global scale alone, and the geographical dimensions of uneven development are poorly worked out" (N. Smith, 2008: 6-7). This quote usefully illustrates that while certain forms of core-periphery thinking focus on global north/south distinctions, we can understand it instead as a broader pattern that repeats at different scales.

Giovanni Arrighi maps similar shifts in accumulation regimes, but instead of Kondratieff waves he focuses on shifts between hegemonic centers of financial power that are, echoing Gramsci, able to represent their interests as the general interest or "common sense" of the system as a whole (Arrighi, 2010: 29). Arrighi argues that hegemonic transitions involve institutional innovations that alter the "mode of operation of the system in a fundamental way", rather than simply changing leadership roles in an otherwise invariant system (ibid: 28). These hegemons are defined by a particular fusion between financial and state power that is able to bring the world-economy and interstate competition under control and ensure minimal cooperation (ibid: 13). Each successive cycle therefore involves not only an expansion in the geographical and material scale of the world-economy but also with the formation of political structured "endowed with ever-more extensive and complex organizational capabilities to control the social and political environment of capital accumulation" (ibid: 14-15). When a particular hegemonic arrangement begins to weaken as a result of declining profitability in key industries, the leading capitalist power turns to financialization to maintain its position of supremacy, though this is unable to resolve the accumulation problem for the system as a whole and serves to funnel capital towards hegemonic challengers. The order eventually enters a period of "systemic chaos" in which the rules and norms of the previous hegemonic configuration come under increasing attack from counter-hegemonic forces (whether in the form of competing states, capitalist fractions, or social forces from below):

> As systemic chaos increases, the demand for 'order'…tends to become more and more general among rulers, or among subjects, or both. Whichever state or group of states is in a position to satisfy this system-wide demand for order is

> thus presented with the opportunity of becoming world hegemonic (Arrighi, 2010: 31).

The question then, for the contemporary context, is whether the crisis we're living through today merely signifies a crisis of neoliberal hegemony, requiring a shift to a new regime of capital accumulation supported by a novel constellation of hegemonic power, or a systemic crisis of capitalism itself, which can only be resolved through a transition to a new kind of world-system (whether one that is more progressive or regressive). Wallerstein argues that we are currently living through a *systemic* crisis that will give way to a new world-system. He believes that secular trends towards rising costs for capitalists (in the form of taxes, wages, and environmental considerations), along with declining opportunities for profitable investment and the depletion of non-integrated populations to turn to for cheap labor, means that capitalism is approaching an "asymptote" in which the game of accumulation will "no longer be profitable for capitalists" (Wallerstein, 2013). Wallerstein recognizes that neoliberalism has attempted to roll back all these rising production costs by cutting wages, re-externalizing environmental costs, and cutting taxes, but he believes that its limited success (seen in skyrocketing indebtedness and slowing GDP growth since 1980) shows that capitalist strategies are delivering diminishing returns in their capacity to sustainably restructure the global economy (Wallerstein, 2004: 86). Therefore, he argues that we will be witnessing an era of "wild fluctuations in all institutional arenas of the world-system", one marked by eruptions of violence, financial instability, and the emergence of transformative actors seeking to push states in more authoritarian or socialist directions (more-or-less what we are experiencing today) (ibid: 87-88).

Arrighi is more ambiguous regarding the prospects of a novel capitalist restructuring, but he believes like Wallerstein that the capitalist world-system is reaching an asymptote that will challenge its capacities to resolve the present crisis. In his framing:

> Capitalist power in the world system cannot expand indefinitely without undermining interstate competition for mobile capital on which the expansion rests. Sooner or later a point will be reached where the alliances between the powers of state and capital that are formed in response to this competition become so formidable that they eliminate the competition itself and, therefore, the possibility for new capitalist powers of a higher order to emerge…It is as if the modern system of rule, having expanded spatially and functionally as far as it could, has nowhere to go but 'forward' towards an entirely new system of rule or 'backward' towards early modern or even pre-modern forms of state- and war-making (Arrighi, 2010: 19, 80)

In other words, Arrighi believes that the geographic scale and military power of the current US hegemony means that the kind of hegemonic transition needed to solve contemporary global challenges and revive capitalist dynamism may no longer be possible, which may require – in the words of Geoff Mann and Joel Wainwright – nothing less than a "Keynesian world state" (Mann & Wainwright, 2018: 125). For Arrighi, this situation will resolve either through the creation of a "truly global empire" imposed by the U.S. that restores order through military power and "protection payments" from the emerging capitalist centers of East Asia, or a fragmentation of the system into competing political-economic blocs and "endless worldwide chaos" (Arrighi, 2009: 7). He suggests that the contemporary anomaly relative to past patterns of world-system transitions, in which emerging accumulation centers are financing the leading capitalist power rather than the reverse, and whose power is being structurally reinforced rather than weakened by such a relationship, shows that such a phase-transition may be taking place (Arrighi, 2010: 15-16).[68] Arrighi also considers the possibility of a new hegemonic configuration led by China that results in a more egalitarian and sustainable capitalist world-system (Arrighi, 2009), though he and Beverly Silver recognize that the task facing any would-be incipient hegemon involves significant ecological and social challenges:

> Any new world-scale material expansion presupposes a vastly different social, geopolitical, and ecological model…It presupposes an alternative path to the resource-intensive Western model of capitalist development – one that is more labor-absorbing, less resource-wasteful, and *not* premised on the *exclusion* of the vast majority of the world's population from its benefits (Arrighi & Silver, 2011: 68).

While a daunting task, Silver and Arrighi leave it open as to whether this will be achieved via a new wave of capital accumulation underpinned by a new hegemonic constellation, or whether this will necessarily force a transition beyond capitalism.

Both Wallerstein and Arrighi provide useful analyses of the contemporary structural crisis of capitalism, and my own approach is deeply indebted to their work. From my view, the key limitation of their work is that it is not sufficiently multi-dimensional to truly understand the complexity, numerous causal drivers, and possible trajectories of the 21st century crisis. On Wallerstein's part, I agree with his bold claim that the capitalist world-system is confronting a "bifurcation" that will most likely result in some form of post-capitalist order in the coming decades (whether progressive or regressive). However, he does not integrate an analysis of the biophysical parameters (especially climate and energy) that are necessary to understand *why* this is the case or *how* the crisis might unfold, nor does he consider the role played by technological change

[68] Arrighi later argues though that the Iraq war debacle represented the US's failed attempt to become a world empire, which has "not eliminated but nonetheless greatly reduced the chances that a Western-centered global empire will ever materialize" (Arrighi, 2007: 7).

(as a source of both potential solutions to capitalist crisis and new catastrophic risks). Instead, while his analysis is prescient on the whole, it remains at a level of generality that is unable to make specific predictions beyond the claims that we are entering a prolonged period systemic turbulence, that capitalism will end sometime in the next half century, and that some (under-specified) form of global authoritarianism or socialism will eventually emerge as a result (Wallerstein, 2004: 76-86). As we will see in chapter six, I agree with the broad contours of Wallerstein's analysis, though I believe we can go much further in understanding the key causal drivers of global systemic crisis, the feedbacks between them, their possible trajectories, and the contours of the possible post-capitalist orders that may emerge in their wake.

Arrighi, on the other hand, provides a unique and useful perspective for thinking about the crisis facing the contemporary American led liberal order. I agree with his claim that the contemporary world-system "has nowhere to go but 'forward' towards an entirely new system of rule or 'backward' towards early modern or even pre-modern forms of state- and war-making" (Arrighi, 2010: 80), though I have a different interpretation of what this means and foreground different causal drivers (to be discussed in chapter six). Like Wallerstein, I believe the key shortcoming in Arrighi's approach is that it does not include critical processes like climate change, food production, energy depletion, and technological change in its analysis of systemic cycles of accumulation and the contemporary global crisis. For this reason, it can only provide faint outlines of the sort of future towards which the world-system is headed (whether "forward" or "backward"), and it leads to an overly optimistic account of the potential for a more equitable and sustainable China-led global capitalist order (though he is not without reservations on this point) (Arrighi, 2009: 389).

Other contemporary Marxist analyses of the present crisis go further by integrating these biophysical parameters like climate and energy, though in a less than systematic way. William Robinson, for example, provides a more comprehensive treatment of the contemporary crisis from a "global capitalist" (rather than world-systems) perspective,[69] one that recognizes it as a multi-dimensional crisis that will likely result in a catastrophic break from capitalism's historical trajectory – and possibly even "a collapse of world civilization and degeneration into a new 'Dark Ages'" (Robinson, 2014: 5). Yet the vast majority of his analysis focuses on the economic crisis and its management by the transnational capitalist class, while problems like climate change, energy depletion, political violence, and non-state terrorism are approached more as external "stressors" that amplify the crisis of capitalism (ibid: 229-230), rather than critical parameters in their own right that must be systematically engaged to understand how the crisis of capitalism will unfold.

David Harvey provides another deep and comprehensive analysis of the present crisis that acknowledges the importance of climate change and resource constraints, but only in a limited way. For example, he is aware of the potentially serious problem of oil depletion, though he more or less echoes the dominant common sense among economists that price rises in response to perceive scarcities will simply make unconventional

[69] This perspective emphasizes, rightly I believe, that WST approaches (especially Arrighi's) tend to overplay the centrality of inter-state competition for mobile capital as the key driver of system evolution. Instead, Robinson suggests that the transnationalization of production processes, investment, and finance over the past 3-4 decades shows that it is somewhat anachronistic to think in terms of competing "national capitals", and that we must think in terms of the hegemony of transnational capital rather than individual states (Robinson, 2010). However, Robinson's "transnational" perspective can also be over-stated in a way that downplays the continuing salience of inter-state competition between national capitals (witness for example ongoing struggles between the US and Chinese IT sectors).

reserves more profitable to exploit, thereby downplaying the problem without considering the deeper trend towards net energy decline (Harvey, 2010: 83). While he recognized the "possibly fatal" implications of climate change, he believes this will create sufficient profitable opportunities for "disaster capitalists" to sustain the accumulation process, while technological innovation and resource substitutes should be able to overcome any perceived environmental scarcities (Harvey, 2014: 249, 260). This last claim could have come straight from an ecomodernist or growth-apologist discourse; more importantly, it does not systematically consider the biophysical constraints that climate change, energy depletion, and agricultural crisis will impose on efforts to restore and sustain continuous accumulation. Despite this, Harvey makes a strong case that expectations of a continued 3% annual compound growth trajectory should be seriously questioned, which would mean finding profitable investment opportunities for an extra $2 trillion in 2020 and $3 trillion in 2030 (compared to $6 billion in 1970), which would require exponential expansions in infrastructures, urbanization and the workforce (Harvey, 2014: 228). He concludes that

> capital can probably continue to function indefinitely but in a manner that will provoke progressive degradation on the land and mass impoverishment, dramatically increasing social class inequality, along with dehumanization of most of humanity, which will be held down by an increasingly repressive and autocratic denial of the potential for individual human flourishing (in other words, an intensification of the totalitarian police-state surveillance and militarized control system and the totalitarian democracy we are now largely experiencing) (ibid: 220).

This is certainly a possible trajectory. But without systematically integrating an analysis of climate change, energy depletion, agricultural crisis, and the catastrophic risks posed by emerging technologies – instead giving us merely an agglomerationist analysis of (some of) these problems – Harvey is unable to envision, and may downplay the likelihood of, an imminent catastrophic discontinuity in the global capitalist system, instead sketching a vague (though plausible) future of gradual and steady decline.[70]

Why, despite being an approach that studies the "totality" (Anievas, 2010; Rosenberg, 1994), or that aims to "perceive the whole" (Wallerstein, 1974a: 10), do Marxist approaches tend to neglect or at best acknowledge biophysical factors that are critical for understanding the present crisis? To some extent it is simply a result of the biophysical blindness or socio-centric approaches that pervades the social sciences (Connolly, 2017a; Deudney, 2000), though we might also highlight the limitations of their methodological and ontological commitments. From this view, the primary problem with (most) Marxist approaches is that their analyses are focused on the dynamics of capitalism as a closed political-economic system, rather than integrating the latter within a broader multi-dimensional complex systems ontology. In part this flows from the way in which capitalism is understood – either as a "totality" or as a "world-system". From this understanding, as bequeathed by the Hegelian-Marxist tradition, the structures and

[70] An insightful article by Chase-Dunn and Kirk Lawrence begins to move beyond some of the limits just described in WST and other Marxist analysis of the planetary crisis, which enables them to provide a more clear articulation of possible future trajectories. They outline 3 possible futures: 1) another round of US economic hegemony based on comparative advantage in new industries (e.g. bio- and nanotechnology); 2) a world-system "collapse" marked by the emergence of hegemonic rivalry among core states, deglobalization, financial meltdown, ecological disaster, and resource wars; and 3) the emergence of a democratic and multilateral global governance structure that restores the environment and reduces global inequality (Chase-Dunn & Lawrence, 2011: 274). They note that rising energy costs probably slant the system towards chaos, and that any sustainable world-system would entail a "low-energy global state" that involves a reduction in world-systemic complexity (ibid: 277, 282). Thus they are more aware of the constraints imposed by biophysical parameters on world-systemic evolution, but their approach remains more intuitive than systematic in this regard. It rightly recognizes the possibility of an imminent systemic rupture that leads either to the emergence of a new world-system or a protracted process of "collapse", but I believe we can integrate these parameters in a more systematic way by synthesizing Marxist political economy with quantitative approaches in climate, food, and energy system modeling. The latter is needed to answer questions like: is the rate of emissions reductions needed to stabilize climate at 1.5-2 degrees C compatible with continuous capitalist expansion? If not, then how quickly do we need to transition to a post-growth system? What is the current rate of oil depletion and what rate of discovery, or development of renewable energy technology, would be needed for global capitalism to avoid a crippling energy shock? How will climate impacts at 1.5, 2, 3 degrees C (and beyond) of warming impact global capitalism by disrupting food and financial systems? How soon, and to what extent, might declining rates of food production growth combined with climate stressors deliver destabilizing food system shocks? What sort of technological innovations, and at what rate, would be needed to stave off these crises, and what other problems might these innovations create? These are the sort of questions, I believe, that a more multi-dimensional and synthetic approach should be able to help us answer.

properties of both the whole and the parts flow from the core logic that defines it, understood in terms of the dominant mode of production.[71] In practice this often leads Marxists to focus on the dynamics of global capitalist expansion rather than situating capitalism as one (albeit "ecologically dominant") system embedded within a broader space of overlapping ecological, technological, infrastructural, subjective and affective systems (Jessop, 2000).

These methodological and ontological limitations have direct consequences for Marxist crisis theory and its analysis of the contemporary planetary conjuncture. As we've seen, Marxists primarily focus on political-economic crises driven by the internal contradictions of the capitalist system, resulting in crises of overaccumulation (too much surplus capital chasing too few investment opportunities), overproduction (insufficient demand to realize the value of produced commodities), or financial collapse (widespread debt defaults followed by credit tightening). The crisis dynamics of interest are therefore conceived to be those "internal" to the circuit of capital, whereas crises originating in the domains of climate, food production, energy, non-state terrorism, supply chain and infrastructure disruption, etc. are conceived as "external" shocks that are largely outside or peripheral to Marxist analysis. While undoubtedly crucial for understanding the contemporary crisis conjuncture, this framework provides Marxists with limited capacities to map and anticipate the complex crisis configurations emerging from the climate-financial-economy-energy-food-health nexus that will be increasingly significant in the coming decades. Thus we need a new "crisis theory" that is indebted to while

[71] For example, as Teschke & Lacher argue, while the notion of intersecting but relatively autonomous logics is unproblematic for those of a Weberian persuasion, such a view is less tenable for the Historical Materialist who conceives historical epochs as defined by the configuration of forces and relations of production; otherwise one risks falling into "bourgeois" social science (Teschke & Lacher, 2010).

going beyond Marxist approaches by integrating them with the work of climate scientists, systems theorists, ecological economists, and others investigating the "emerging [socio-ecological] architecture of global crisis" (e.g. Homer-Dixon et al, 2015; Ahmed, 2017).

Overall, on one hand, there is a need to broaden the scope of Marxist approaches in order to account for other key dimensions of the 21st century crisis convergence – especially the dynamics of the earth system, energy and food systems, information systems, and new technologies of mass destruction. On the other hand, there is a need for a more open and fluid framework for understanding "systems" that avoids simply gathering such parameters into a functional whole (or "totality") defined by a singular or bimodal logic (i.e. the logic of capital, or the logic of capital plus geopolitical competition). Instead we need to think of a dynamic assemblage of moving parts that can only be understood through their relations but that don't form a functional whole that subordinates its parts, which could be envisioned as an open-ended field of reciprocal interaction between political-economic, ecological, and technological systems in which critical events in parameters that are shaped by yet irreducible to capitalism (e.g. technological innovation, microbial evolution, state securitization) can ripple across and transform the entire field.[72] Rather than an organic totality, which exaggerates functional subsumption and misses the real-world spatial and temporal complexity of socio-ecological crisis dynamics, we should instead develop new concepts to capture the globally integrated yet uneven mesh of intersecting climate-financial-economic-energy-food assemblages – a "multiplicity" of systems that is "neither one nor many" (Deleuze

[72] The approach developed here will still at times make use of the term "world-system" with the caveat that this should be understood more as what Deleuze and Guattari would call an "assemblage". From this perspective, the regional, infrastructural, political and cultural subsystems of the capitalist world-system/assemblage must be understood in their relative autonomy rather than simply forming functional appendages to the reproduction of capitalism, but neither can they be understood apart from the gravitational pull of the ecologically dominant logic of capital accumulation.

& Guattari, 2004), that cannot be subsumed within a "core logic", but that can nevertheless be analyzed as an emergent entity that is irreducible to the sum of its parts.

While the majority of Marxists in this sense have yet to integrate their analysis of capitalism within a broader systems ontology, the broad sub-approach known as "Ecological Marxism" has begun to move in this direction, especially in regards to ecology and the earth system. It is therefore a productive resource to turn to for a deeper analysis of the contemporary crisis of capitalism, and it will bring us closer to the alternative Deleuzian and CT-inspired framework developed in this next chapter.

Ecological Marxism

The field of Ecological Marxism has grown over the past three decades as scholars in the HM tradition have rediscovered the ecological dimensions of Marx's thought, which were occluded by the "productivist" leanings of Marxist-Leninism in the early 20th century (Foster & Burkett, 2016). Marx has often been accused of being an anti-ecological thinker, with many assuming that he failed to perceive the role of nature in the creation of value,[73] that he understood the reproduction and expansion of capitalist production as a linear process unconstrained by biophysical conditions, or that he advocated a "Promethean" mastery of nature. But Eco-Marxists, especially John Bellamy Foster and Paul Burkett, have convincingly demonstrated the fallacy (or at best one-sidedness) of these views by going back to what Marx actually said and uncovering a

[73] Marx is often accused of propounding a "labor theory of value" that designates human labor as the source of all wealth, while natural resources and environments are somehow devoid of all value until being transformed by human labor. However, Marx's theory of value must be understood not as a timeless theory of how "value" in the abstract is produced, but as an explication of specifically capitalist processes of value production and exchange (Foster, 2000: 167). In this sense, it is not Marx but *capitalism* that devalues the input of nature.

sophisticated ecological critique of capitalism (Foster, 2000; Burkett, 2006). But beyond merely providing an ecological rehabilitation of Marx, Eco-Marxists also provide one of the most productive starting points for understanding socioecological dynamics in the context of the Anthropocene, especially the intertwined evolution of capitalism and the earth system.

We can pick out at least two strands of Ecological Marxism. The first follows Engel's late attempts to formulate a "dialectics of nature", which investigates the emergence and relative autonomy of geological, biological, ecological, and social laws and tendencies, understanding how the latter emerge and are conditioned by the former (Foster, 2000; Foster & Burkett, 2016; Angus, 2016; Malm, 2018; Wark, 2015a; Clark & York, 2012). The second, on the other hand, follows Neil Smith's emphasis on the "production of nature", arguing that capitalism is not simply a social order that interacts with and degrades an external "Nature" but in fact aims to *produce* nature and to a significant extent *subsumes* it within its reproduction process, such that any notion of relative autonomy becomes anachronistic (Smith, 2008; Moore, 2015; Harvey, 1996; Castree, 2000).

In the first approach, developed by John Bellamy Foster, Paul Burkett, McKenzie Wark, Ian Angus, and Andreas Malm, the emphasis is on Marx's concept of the "metabolic rift", which begins from understanding how social relations become *separated* from their underlying ecological basis under the hegemony of capitalist exchange-value relations. This does not mean that pre-capitalist formations were always in "harmony with nature", but that the discipline of capitalist competition creates uniquely powerful and structural selection pressures towards forms of production that degrade and destabilize their socioecological milieus – including the soil, forests, aquifers, workers, and pre-capitalist communal ties. In Marx's time the metabolic rift referred to a disruption in the nutrient cycles through which the soil in pre-capitalist agriculture was able to regenerate itself. As subsistence farmers were forced off their land and industrial export-oriented agriculture came to dominate the countryside in the 19th century, the nutrient-rich waste products of crops were disposed of in cities rather than being returned to the soil to replenish it (Foster, 2000: 163). In the 19th century this led to a crisis of soil fertility, which generated increasing demand for fertilizer imports to regenerate the soil. While this era experienced significant advances in understanding soil chemistry, seen especially in the scientific work of Justin Liebig (a key influence on Marx's theory of metabolic rift), the pressures of market competition hindered the capacity of farmers to adopt more sustainable methods, instead fueling the development of a series of technical fixes to continue sustaining high yields at the lowest possible cost, and in turn leading to the expansion of existing ecological problems and the emergence of new ones.[74] The metabolic rift has in this way become progressively globalized and now manifests through disruptions in the earth's circulation systems and biogeochemical cycles – including the carbon, nitrogen, phosphorous, hydrological and other cycles (Foster et al, 2011; see also Wark, 2015a).

Scholars from this approach base their work on a synthesis of HM and emerging forms of scientific materialism, which was developed in germinal form in Engels's

[74] For example, as Richard York and Brett Clark explain, the need for fertilizer imports to sustain high yields in the 19th century led to "guano imperialism" in Peru and Chile, which globalized the metabolic rift by draining South American colonies of their soil nutrients; further exhaustion of the soil in Europe then led to the development of the "Haber-Bosch process" for fixing nitrogen from the air to produce new fertilizers for the soil, eventually producing a "rift" in the global nitrogen cycle and contributing to the eutrophication of rivers and oceans (Clark & York, 2012: 28).).

“dialectics of nature”. As JBS Haldane describes in his foreword to the *Dialectics of Nature,* this philosophy

> lays particular emphasis on the interconnection of all processes, and the artificial character of the distinctions which men have drawn…between the different fields of human knowledge such as economics, history, and natural science (Haldane, 1940: xv).

Thus the *Dialectics of Nature* can be seen as an early attempt to integrate Marx’s theory of history with a broader scientific materialism that expressed the “essential unity of method between the natural and the social sciences” (Foster, 2000: 7). As Foster explains, this perspective comprises an ontological and epistemological materialism, which shows how the social world emerges from and is constrained by the biological, while the material world has laws or at least law-like tendencies that can be scientifically known (ibid: 2). This approach tends to be more amenable to engagement with the natural sciences. For example, Foster and Burkett call Engel’s *Dialectics of Nature* a “precursor of contemporary complexity theory” (Foster & Burkett, 2006: 111), since both approaches attempt to develop a general systems framework to understand processes of self-organization at all scales of nature and the emergence of progressively differentiated levels from more ancient levels. Similarly, Ian Angus explicitly relates the dialectics of nature to contemporary earth system science, claiming that “the fundamental dialectical concept of the transformation of quantity into quality has been absorbed into scientific thought under labels such as emergence, quantum leaps, and punctuated equilibrium” (Angus, 2016: 64). At the same time, while these approaches are aware of the pitfalls of Neo-Malthusian determinism, which often ignore how natural limits are co-constituted by social relations and their inequalities, they engage directly with the implications of biophysical realities like population growth, energy scarcity, soil depletion, and other looming environmental scarcities, signaling that these are not simply “external” limits requiring technocratic management but problems that are fundamentally shaped by capitalist social relations (Foster, 2011; Wark, 2015a; Angus, 2016).

The second approach, on the other hand, fears that the “dualist” understandings of socio-environmental change followed by these Ecological Marxists risks both 1) reproducing Malthusian tendencies to naturalize limits, and 2) evoking apocalyptic narratives that downplay the potential for sociotechnical creativity to obviate such limits *if* freed from capitalist class relations. In this strand, pioneered by Neil Smith, David Harvey, Noel Castree, and Jason Moore, the idea of a relatively autonomous “Nature” is rejected in favor of a thesis of the “production of nature”. In this view, while the existence of a pre-human nature shaped by physical laws is not denied, their emphasis is on how capitalism has so powerfully transformed the multiple dimensions of the earth system that it is meaningless now to speak of an “external nature” with its own dynamics independent of social forces. For example, Castree critiques what he considers the “dualistic mind-set” implicit in Engels’s (and by extension other Eco-Marxists’) emphasis on “nature’s dialectical laws, its non-identity with humanity and its relative autonomy” (Castree, 2000: 14): Similarly, Neil Smith critiques accounts of nature as “external to society, pristine and pre-human, or else as a grand universal in which human beings are but small and simple cogs…with the development of capitalism, human society has put itself at the center of nature” (N. Smith, 2008: 7).

Following Smith, the recent work of Marxist environmental historian Jason Moore aims to rethink WST and Marxist crisis theory in a way that emphasizes the co-constitutive nature of social and ecological relations. For Moore this requires understanding social organizations not as discrete entities that act *on* and defile an external "Nature-in-general", but that act *through* the web of life, and in doing so co-constitute themselves alongside "historical-natures" (Moore, 2015: 5).[75] Moore's approach begins from the basic insight that the engine of capitalism has historically depended on locating and appropriating a steady flow of what Moore calls "cheap nature" – primarily food, energy, labor-power, and raw materials (ibid: 53). Early capitalism, in this sense, triumphed because of its ability to appropriate and realize the potentialities of uncommodified cheap natures worldwide, and its continued success has been premised on its ability to continuously transform itself in successive "world ecological regimes", defined by Moore as hegemonic regimes (following Arrighi) based on "norms through which labor-power is organized, food is grown and exchanged, resources extracted, and knowledge developed" (ibid: 113). These regime transitions enable the entwined agencies of capital and states to find new ways to harness the work-energy of humans and nature to service the ends of capital accumulation, often through new forms of imperialism and technoscientific revolutions, while also externalizing its costs (ibid: 94). Whereas Marxists traditionally focus on the circuit of capital accumulation and the exploitation of labor-power internal to that circuit, Moore instead foregrounds what he calls a "dialectic of exploitation and appropriation", in which the conditions of accumulation and

[75] Moore argues that his framework moves beyond residual forms of "dualism" in other Ecological Marxist approaches that posit the metabolic rift as a *separation* between capitalism and nature. From my view this is more a matter of conceptual emphasis than theoretical substance, since both Moore and earlier forms of Ecological Marxism posit a capital-nature dialectic in which each reciprocally transforms the other (Foster et al, 2011). Yet Moore places greater emphasis on the underlying unity of capitalism and nature (hence his use of "capitalism-in-nature"), while others like Bellamy Foster and Malm emphasize the unique emergent properties of the social and the need to analytically distinguish it from the natural (Foster, 2016; Malm, 2018). Whatever the merits of Moore's conceptual innovation, I find his socio-ecological reworking of WST and Marxist crisis theory to be the most useful element of his approach.

exploitation depend on “extra-economic processes that identify, secure, and channel unpaid work outside the commodity system into the circuit of capital” (ibid: 17).[76]

This framework gives Moore a unique and productive angle on understanding the cyclical and secular crises of capitalism, which he frames as a matter of the interlinked tendencies of surplus capital to rise in the zone of commodification and of the “world-ecological surplus” to fall in the zone of reproduction (ibid: 91). When capitalists can invest relatively small amounts of capital while appropriating large volumes of unpaid work/energy, the costs of production fall and rate of profit rises, creating a “high world-ecological surplus” (ibid: 95). However, over time the rate of ecological surplus diminishes as the sources of work-energy – working classes, forests, aquifers, oilfields, coal seams, etc – reach their limits, leading to crises of “underproduction” (ibid: 105). In this sense, the problem for Moore is not simply one of too much capital facing too few investment opportunities, as Marxists like David Harvey usually emphasize (Harvey, 2010), but one of how this tendency interacts with the tendency towards a falling ecological surplus. In Moore’s words: “the tendency of surplus capital to rise, and of ecological surplus to fall, constitute an irreconcilable contradiction between the project of capital and the work of the natures that make that project possible” (Moore, 2015: 114). The big question for today’s crisis is then:

> Are today’s frontiers of appropriation of sufficiently great mass – in terms of work/energy – that they can restore the Four Cheaps, provide investment outlets for now massively over-accumulated capital, and revive accumulation? And if they are of sufficiently great mass, how long can such a revival be sustained (ibid).

[76] Quantitative estimates for unpaid human work (mostly done by women) vary between 70 to 80% of world GDP, and for ecosystem services between 70 and 250% of GDP (Moore, 2015: 64).

Overall, rather than a separate capitalism-in-crisis acting on, depleting and destroying an external Nature, Moore argues that capitalism *is* a specific historical-nature that has reached its historical limits, thereby paving the way for the emergence of new historical-natures (rather than the destruction of "Nature" in the abstract). Moore therefore believes that he provides a more hopeful narrative of the coming crisis as an opportunity for the emergence of a post-capitalist socioecological regime, rather than an impending apocalypse:

> Absent the specification of historical natures that encompass humanity, nature-in-general has driven green politics into an 'either/or' position: sustainability or collapse…if the limits of capitalism today are limits of a particular way of organizing nature, we are confronted with the possibility of changing humanity's relation to nature (ibid: 19, 86).

Beyond Ecological Marxism

Moore's framework presents a provocative conceptual challenge to earlier Ecological Marxist approaches. Though earlier Eco-Marxists were clearly aware that Marx's labor-nature dialectic requires thinking in terms of processes of reciprocal transformation rather than simply dualistic interaction between self-same substances, there is nonetheless a tendency in this literature towards dualistic thinking, for example when the metabolic rift is thought in terms of a *separation* between humans and nature.[77] Moore also adds to these earlier accounts by highlighting the biophysical dimensions of the structural crisis of capitalism with his concept of the falling ecological surplus, while others like Foster focus on dynamics within the circuit of surplus-value production and

[77] For example, Foster et al write that "a deep chasm has opened up in the metabolic relation between human beings and nature" (Foster et al, 2011: 7). Such dualistic language appears to be the source of Moore's critique. While Foster elsewhere recognizes the human-nature metabolism as a double internality (Foster, 2016), his tendency to convey the metabolic rift as a *separation* between humans and nature is misleading. Instead, following McKenzie Wark, the metabolic rift should not be understood as a rift *between* humans and nature, but rather a rift *within* the biogeochemical cycles of the earth itself (Wark, 2015b).

exchange (e.g. overproduction, monopolization, financialization, and the rising organic composition of capital[78]) to explain the crisis (Foster & McChesney, 2013). Given that widespread tendencies towards diminishing rates of "Energy Return on Investment" (EROI) (which Moore reframes as "Energy Returned on Capital Invested") in the energy and food sectors are seen by many to be significant dangers to the short and long term health of the global economy (Ahmed, 2017; Galbraith, 2014; Homer Dixon et al, 2015), Moore's emphasis on the ecological surplus and long-term exhaustion of cheap nature appears to provide deeper insight into the socio-ecological roots of the present structural crisis than more traditional Marxist approaches.

However, the limits of Moore's framework become clear in the way he conceptualizes the contemporary *ecological* crisis. Moore spends much time critiquing other Marxists for narrowing their focus on the problem of what capitalism *does to nature* rather than how nature *works for* capitalism (Moore, 2015: 27), and he while he doesn't ignore the first problem he seems to underplay it in a way that contributes towards a misplaced optimism: "Too often…the revenge of nature appears as impending cataclysm, and too rarely as a "normal" cyclical phenomenon of capitalism" (ibid: 79-80). While Moore recognizes that the present crisis may be unique, for him it seems primarily a problem of capitalism's ability to locate and extract cheap nature than of an abrupt transformation in the state of the earth system. Thus the limits of his attempt to flatten the historical dynamics of capitalism and natural processes into a single dialectic becomes

[78] Referring to the ratio between fixed capital (machinery) and variable capital (human labor-power). In the traditional Marxist understanding, the tendency towards a falling rate of profit is driven by the long-term rise in fixed relative to variable capital, which diminishes opportunities for surplus-value, given that human labor-power is the primary source of surplus-value (Harvey, 2014).

evident, which obscures the agency of the earth system and underplays the stakes and scale of the crisis that the Anthropocene heralds.

More generally, we can say that the approach of Neil Smith, Harvey, and Moore risks subsuming the ecological dimensions so completely that we are given a "politics without ecology" (Walker, 2005), which simply ignores the fact that critical transitions in the earth system will place limits on the survival and flourishing potential of any post-capitalist socio-ecological order. Moore is right to be hopeful that an eco-socialist world order structured according to emergent systemic principles of ecological regeneration could over time heal the biosphere, but we need a much deeper appreciation of the earth system's agency in determining a new epoch that will to a great extent exceed humanity's regenerative capacities. As Isabelle Stengers argues, this means thinking through the Anthropocene not simply as a co-production of humanity and nature but as the "intrusion of Gaia": a "ticklish assemblage of forces that are indifferent to our reasons and our projects", and which heralds "the intrusion of a form of transcendence into our history" (Stengers, 2015: 47-48). While Eco-Marxists like Moore, Castree and Smith would resist the language of transcendence here, Stengers is right that we need to take account of an agency that exceeds and is to a large extent indifferent to our social relations and projects. Thus there is no symmetrical co-production of society and nature, but rather an assymetric reciprocal determination of the earth system and capitalist world-system in which the forces of the former reign supreme and will continue to unleash cascading ecological changes even if capitalism were abolished yesterday. Geologists Jan Zalasiewicz and Mark Williams effectively express this point:

> what humanity seems to be doing is not so much creating the entirety of a new global warming phenomenon, but rather lighting the blue touchpaper for an

> event that will acquire its own momentum, and that will then reverberate around the Earth according to its own internal dynamics (Williams & Zalasiewicz, 2012: 262).

It is for this reason that some version of Engel's *Dialectics of Nature* that investigates the emergence and mutual envelopment of relatively autonomous geological, ecological, and political-economic strata is needed. While Foster, Burkett, Malm, and other "methodologically dualist" Eco-Marxists can at times over-emphasize the separation between capitalism and nature, they understand better than Moore that dialectical co-production does not obviate the existence of (open and permeable) system boundaries. Further, understanding such boundaries is needed to adequately map the levels, scales, and feedbacks between the earth and world-systems as *coupled socio-ecological systems*. In short, while it would be wrong to think of the earth system as merely "natural" and the world-capitalist system as merely "social", it is nonetheless true that they are each relatively autonomous, with their own emergent dynamics and powers that are co-constitutive but irreducible to the other (Malm, 2018). In this sense, the earth system *includes* the capitalist world-system as a crucial sub-system that is altering the structure and behavior of the whole, but we cannot efface the deep historicity of the earth system (as well as the limits posed by oil, water, and soil depletion) as fully subsumed within the (geologically infantile) capitalist system. This requires understanding the earth system crisis as a crisis in geological time, one which vastly exceeds the temporality of capitalism and will take on its own self-reinforcing dynamics that escape the productive or shaping potential of humanity (Davies, 2016).

While I therefore agree with Foster, Burkett, Malm, and Wark in following the "dialectics of nature" tradition in Ecological Marxism, I will argue that an alternative theoretical framework is needed to more adequately map these systems, their relations, and their possible future trajectories. As noted previously, Foster and Burkett already point us to a possible alternative when they discuss Engel's dialectics of nature as a "precursor to complexity theory" (Foster & Burkett, 2006). However, rather than updating their theoretical frameworks to accommodate the insights of contemporary CT and build a novel synthesis of Marxist theory and earth systems science, Ecological Marxists have to this point been content to simply point towards the parallels while keeping their classical Marxist framework intact. Engels' dialectics of nature points us in the right direction by offering a framework that integrates the study of social and ecological processes, though we need an alternative that is better able to capture the multi-level dynamics, relations, instabilities, feedbacks and entangled transitions occurring in the contemporary earth system and capitalist world system.

In particular, like WST before it, by depicting capitalism as a smooth "totality", Ecological Marxism tends to flatten multiple scales of socioecological metabolism into a single capital-nature dialectic, to ignore dimensions of the problem that are entwined with yet irreducible to the logic of capital (e.g. geopolitical competition, technological change, violence and securitization, cognitive-affective orientations), and to paint a simplified image of system transition by hoping for a total "negation" of the logic of capital.[79] In this sense, rather than a complex and intersectionally uneven geography of socioecological metabolisms at different scales, which are constrained by but not

[79] For example, Foster et al argue that resolving the crisis requires a "complete break with the logic of capital", though they acknowledge that this doesn't vitiate the need to take beneficial actions within the system that go against its internal logic (Foster et al, 2011: 86). From a Deleuzian perspective, this is not necessarily wrong, though it tends to simplify the problem and solution-space, since it ignores other "logics" that constrain global sustainability initiatives (e.g. the "logic of security"), and it doesn't say much about what breaking free from the "logic of capital" would mean in practice on a global scale, other than promoting an alternative metabolic order "in which associated producers can regulate their exchange with nature in accordance with natural limits and laws" (ibid).

subsumed within capitalist hegemony, these Ecological Marxist approaches provide a useful but somewhat simplified analysis of both the planetary crisis and solution-space: i.e., capitalism is the problem, and ecosocialism the solution. While I certainly agree with this analysis to a large extent, we need a more multi-dimensional framework that not only enables us to disaggregate these assemblages and capture the geographical unevenness of the current crisis – one that accounts for the relatively autonomous dynamics of regions, nation-states, cities and communities – but that is also thereby capable of grappling with the spatiotemporally uneven and combined nature of the needed socioecological transition (Swilling, 2019).

Further, like WST, Ecological Marxists have (somewhat oddly) only made limited moves to broaden their understanding of Marxist crisis theory in an era of converging climate-economic-financial-food-energy-health crises. On one hand, while Foster speaks of a convergence of political-economic and ecological crises, he does not explore the complexities of *how* they will converge – instead describing them in relative isolation from each other – and does not attempt to map the complex causal chains of socio-ecological crisis and systemic risk that characterize our planetary conjuncture (Foster, 2011; Foster & McChesney, 2013). On the other hand, Moore goes further in integrating an analysis of *how* problems like climate change and resource depletion will intersect with the contemporary crisis of capitalism, though his approach remains limited by the Hegelian-Marxist heritage of totality: instead of a complex multiplicity of converging crises, he identifies a "singular crisis…with manifold expressions…emanating from a singular civilizational project: the law of value as a law of Cheap Nature" (Moore, 2015: 298). This conceptualization is fair in the sense that none of the key dimensions of the contemporary crisis – from climate to energy, food, finance, and health – can be understood or resolved in a just manner without foregrounding the emergent causal agency of capital. However, it risks creating a homogenized image of our planetary metabolism and its crisis dynamics rather than disaggregating and mapping its complex multi-scalar, multi-subsystem, and uneven geographic and temporal dynamics, thereby constraining our analysis of the planetary crisis convergence and its possible future trajectories.

Overall, while Ecological Marxism begins to integrate Marxist analyses of capitalism with a broader systems ontology, it remains, like WST and traditional Marxist approaches before it, constrained by a version of systems theory grounded in 19^{th} century dialectics. As Gilles Deleuze would say, their concepts, "like baggy clothes, are much too big" (quoted in Choat, 2012: 132), which limits the range of their analyses, the questions they're able to pose, and the opportunities for praxis they identify. While they are vital to the approach developed here, we can synthesize them with a multi-dimensional complex systems ontology that can more adequately capture the geographical unevenness and multi-scalar relations that constitute the planetary crisis convergence, as well as including other dimensions of the problematic (especially technology, violence, and cognitive-affective systems) that are ignored by these approaches. To this end, it is proposed that a Deleuzian and Simondonian inspired complex systems ontology – one that situates capitalism not as a totality but as a emergent "attractor" that supervenes on and constrains (without subsuming) a complex multiplicity of psycho-social, technical, infrastructural, and biophysical systems – can help us develop a more comprehensive analysis of the planetary crisis convergence. But to deepen our insight into the parameters of technology, violence, and security, we should first engage with one of the only HM approaches yet developed that systematically engages these domains.

Historical Security Materialism

The work of Daniel Deudney provides a creative extension of HM that allows us to grapple more systematically with the entwined problems of violence, technological change, and political order. The key insight of his "Historical Security Materialist" framework is that the interaction between geography and technology condition and constrain the viability of different modes of political organization (or what Deudney calls "modes of protection") across space and time. The central variable in this analysis is what Deudney calls "violence-interdependence", or the capacity for political actors to wield violence across geographic distance (Deudney, 2000: 80). As new technological capacities enhance the forces of destruction, older modes of protection are made less viable and forced to adapt in order to constrain this emergent violence-capacity. The basic claim is that the interaction between geography and technology, what Deudney calls the "material-context", creates functional imperatives that determine the basic viability of different modes of protection. In his words: "Human political security arrangements are practically constructed mediations between the unchanging natural need for security and the variable and changing constraints and opportunities of the material context" (Deudney, 2007: 59).

The key question, then, for HSM is "what kind of restraints are necessary in which situations in order to achieve security?" (ibid: 33). However, Deudney doesn't simply follow IR realists in reducing the security problematic to the protection of territorial entities from *external* threats, but also includes the protection of populations from the *internal* threats posed by oppressive regimes. The two key “problematiques” Deudney identifies are in this way those of *anarchy-interdependence* and *hierarchy-restraint*, or the problems of restraining both anarchy and hierarchy in different material contexts. As he explains, “security-restraint republicanism…values freedom and opposes tyranny, wants independent actors to self-regulate themselves in order to make centralized control unnecessary, supports centralized political power only where necessary to counterbalance outside threats” (ibid: 21).

Deudney broadly schematizes four periods in which violence capacity and corresponding modes of protection were relatively stable: 1) the “pre-modern” era (to 1500) composed of horses, camels, bows and catapults; 2) the “early modern” era (1500-1800) composed of horses, ocean sailing and navigation, and gunpowder; 3) the “global industrial” era (1850-1945) conditioned by steel ships powered by coal and oil, airplanes, telegraphs, radio, and high explosives; and 4) the “planetary-nuclear” era, composed of jet airplanes, satellites, and intercontinental ballistic missiles (2000: 90). Each era could be considered a kind of “equilibrium” point, while the shifts between them involved “crises” that tipped system equilibrium into an unstable state requiring the emergence of novel political arrangements on an expanded scale. The emergence of gunpowder, for example, made it far more difficult for Feudal lords to defend their fortresses and thereby undermined their viability, making states with large-armies the more viable mode of protection (Herz, 1957).[80] Most recently, the emergence of intercontinental ballistic

[80] Charles Tilly argues that the growing sophistication of artillery enabled by gunpowder in the 15th century came too late to have *caused* the increase in the viable size of states, since processes of territorial state-formation were already underway. However, the increased cost of fortifications to defend against artillery gave an advantage to states enjoying larger fiscal bases, thereby making the latter more viable in the long-term (Tilly, 1985: 178).

nuclear missiles signals the advent of violence-interdependence on a planetary scale, which increasingly challenges the security viability of the modern state-form, requiring new forms of arms control and global governance to restrain (Deudney, 2007). While the planetary-nuclear configuration has (luckily) so far been conducive to restraining great power war and enabling liberal-democratic political forms to flourish, Deudney also notes that the possibility of further advances in science and technology enabling the creation of more advanced destructive capacities (such as biotechnologically enhanced bioweapons) will further complexify the security problematique and could potentially undermine the equilibrium that has so far been conducive to liberal-democratic regimes. The normative challenge for HSM, in the contemporary planetary context, is thus to help is envision political architectures that can navigate between the extremes of anarchy and hierarchy under changing material and technological conditions in order to facilitate the flourishing of human freedom.

Deudney's HSM provides a simple yet elegant framework for incorporating an analysis of "violence-interdependence" as a crucial dimension of the planetary problematic. By ignoring this dimension, Marxists not only lose touch with an important critique of capitalist technology (i.e. that it allows the "anarchy of the market" to proliferate catastrophic technological risks) but also efface questions like: how would ecosocialist societies deal with the problem of security? What forms of surveillance might it entail? And specifically, how would they protect themselves from the catastrophic risks posed by innovative technologies without thereby giving rise to an authoritarian security regime? While Ecological Marxists emphasize that ecosocialism must be a democratic system, to the best of my knowledge they have yet to think through the very real challenges that new technologies, in conjunction with earth system turbulence and the potential for significant energy and food shortages, will pose to the democratic pretensions of any governing system trying to maintain civil order. Without thinking through these problems, ecosocialists risk being blind-sided by the myriad security challenges that they would undoubtedly need to confront should they ever succeed in gaining power.

Deudney's framework is thus important for highlighting these challenges, though by itself it has limitations. First, his framework ignores the political-economic context in which relations of violence-interdependence are embedded and which security practices function to secure. He therefore ignores what we could call the relations of "structural violence" inherent in particular forms of political-economic order (Galtung, 1971), and which are important underlying conditions that often give rise to outbreaks of "actual" violence. These omissions are more understandable when focusing on violence-interdependence between states and militaries. But in an era when the forces of destruction are increasingly democratized, it is critical that we comprehend the underlying relations of structural violence that make outbreaks of actual violence (e.g. non-state terrorism) more likely. Furthermore, integrating an analysis of violence-interdependence with political economy is needed in order to foreground the relations between political-economic structures, technological change, and modes of protection. In an age where new technologies amplifying violence-interdependence are being primarily driven by the private sphere (seen in commercial sector investments in biotechnology, nanotechnology, additive manufacturing, the internet of things, and AI), restraining this emergent violence-interdependence will likely require forms of regulation (if not public control) that challenge the private ownership structure of global capitalism.

Conclusion

Deudney himself points to the possibility of a synthesis between HSM and Marxist political economy (Deudney, 2000), but he does not pursue such a synthesis in his own work. The theoretical framework developed in the next chapter can thus be read in part as the elaboration of a more multi-dimensional complex systems ontology that is able to integrate an analysis of capitalism and the earth system alongside an analysis of violence-interdependence. In other words, it will allow us to investigate the earth system crisis, the crisis of capitalism, the sub-crises of energy and food, and the incipient crisis of violence-interdependence as reciprocally determining dimensions of an emergent planetary problematic that is more than the sum of its parts. The philosophy of Gilles Deleuze, read through the lens of Gilbert Simondon, Complexity Theory, and Marxism, can provide a productive ontological basis for engaging in such a multi-dimensional analysis. The next chapter will elaborate key concepts and insights from Deleuze and Simondon that will form the basis of my alternative theoretical approach.

Chapter Four: Simondon and Deleuze: Individuation, The Problematic, and Assemblages

As we saw in the last chapter, many Marxists are well aware of the severity of the contemporary planetary crisis and likelihood of a systemic rupture in world order and political-economic organization. Yet most of them have only analyzed specific dimension or pairs of its dimensions, which is in large part due to the ontological and methodological limitations of Marxist analysis. Such partial analyses are of course necessary, since multidimensional synthesis can only proceed on the back of the rigors of isolationist analysis, whether of the structural crisis of capitalism, climate change, energy depletion, or any other dimension. However, no matter the challenges, multi-dimensional synthesis is nonetheless essential if we hope to clarify both the nature and complexity of the Planetary Problematic and its “solution-space”. To some this will of course sound incredibly ambitious, though it is arguably no more difficult than providing a rigorous in-depth analysis of any single dimension taken in isolation. The task may be less a heroic one than one of a humble “bricoleur” (Sassen & Ong, 2014), which requires taking advantage of the best isolationist and agglomerationist analyses tackling specific dimensions of the planetary crisis while synthesizing them into an emergent whole. However, such a task requires a theoretical framework that facilitates synthesis, which must be abstract enough to illuminate common patterns, properties, and relations across a diverse array of systems and processes. It should be able to conceptualize the emergence, reproduction, and transformation of systems at multiple scales combining political-economic, ecological, and technological elements, while also understanding the relations and feedbacks between the diverse problems/processes from which these systems emerge and to which they must continuously respond. And it should be able to weave together a map of the planetary conjuncture that combines universality and singularity, understanding the material-energetic-ecological entanglement of all agencies and perspectives (both "human" and "non-human") on the planet today without thereby subsuming them under a universalizing definition of the problems and solution-space. This last criteria is probably the most difficult, especially for a single theorist working from a particular (white, male, and North American) perspective, though I believe the mark of a useful framework is its capacity to continuously deepen and enrich itself through encounters with difference and articulations from diverse perspectives, though the articulation of it developed here will of necessity be a limited one based on my own perspectival constraints.

This chapter will argue that an ontological framework that synthesizes concepts from Deleuze, Deleuze & Guattari, Simondon, and Complexity Theory can help us develop such a map of the Planetary Problematic, one that is open-ended, dynamic, and capable (at least in principle) of synthesizing diverse perspectives without subsuming their differences. While the framework is ontologically Deleuzian, its theoretical and practical ambitions are congruent with Marxism in that it investigates the intersecting political-economic, ecological, and technological relations through which "human" life is collectively produced and reproduced, and aims to enhance individual and collective flourishing through the critique of arbitrary sociopolitical constraints on this flourishing and the affirmation of new ways of life. It provides one possible trajectory for broadening and deepening Historical Materialism in order to bring greater complexity and nuance to its analysis of the planetary crisis convergence, though other pathways are undoubtedly possible as well.

I will begin with an overview of the core ontological insights and key concepts from Deleuze and Simondon that inform my analysis, in particular the concepts of individuation, metastability, and the problematic. I will then undertake a complexity theory interlude in order to illustrate the resonance of Deleuze and Simondon's concepts with its terminology, focusing in particular on the concepts of catastrophic bifurcations and resilience. Finally, I will turn to the work of Deleuze and Guattari where I provide an overview of their concept of assemblages, the capitalist axiomatic, mapping, and minor science, which will be read through the lens of both complexity theory and the Deleuzian/Simondonian concepts surveyed in the first section. The next chapter will then provide a synthetic conceptual overview of what can be called "Planetary Assemblage Theory".

Gilbert Simondon and Gilles Deleuze

The reception of Deleuze's work in the field of IR has been slow, uneven, and selective, with the focus primarily being laid on his collaborative work with Felix Guattari. As Peter Lenco explains, this has involved a tendency to use Deleuzo-Guattarian concepts for the purposes of intriguing and mystifying rather than explaining world politics (Lenco, 2014). There have however been deepening engagements in recent years, with many deploying Deleuze and Guattari's concept of "assemblage" to understand the fragmented consistency and reconstructibility of world politics (Acuto & Curtis, 2014), others illuminating the resonances between Deleuze's ontology and complexity theory-inspired approaches to IR (Bousquet & Curtis, 2011), and a handful like Peter Lenco delving deeper into the philosophical basis of Deleuze's ontology to rethink basic concepts like entity, event, process, and agency in world politics (Lenco 2013, 2014). The approach taken here will follow Lenco in drawing from Deleuze's early work (mainly *Difference and Repetition*) in order to clarify the philosophical stakes of his project (along with his coauthored work with Guattari), though it will also re-read Deleuze through the lens of Gilbert Simondon and with an eye towards a renewed Historical Materialism for the 21st century (or a "minor Marxism" (Holland, 2006)).

Simondon's work is much less known than the work of Deleuze, largely due to the paucity of English translations of his work, but also due to the contingencies of academic publishing and reception that left his work in obscurity relative to thinkers of his generation like Deleuze and Derrida, despite his influence on the latter (Bowden, 2012). In fact, Deleuze's project, while certainly unique, is also congruent with Simondon's ontology in many respects. This is primarily for two reasons: first, both and Deleuze and Simondon begin their projects from a critique of identity and the ontological privilege of the individual, instead developing concepts of difference and "individuation" to illuminate dynamic processes of becoming that fall through the mesh of identity-based thinking. Second, both thinkers develop their process ontologies around what we could call the "problematic-individuation complex", or a conception of Being as the repository of preindividual "problems" from which individuated entities and systems emerge as "solutions" (Scott, 2014). While mainstream IR has traditionally had difficulty understanding the problem of system change, instead beginning with the identity and structure of the present international system, Deleuze and Simondon instead begin from process and pre-individuality and then seek to understand how individuals emerge and stabilize from this flux. Thus their concepts can provide more cognitive and practical traction on a world in "crisis", and can supplement and deepen Marxist approaches to understanding the present crisis while perhaps shedding more light on the contours of not-yet-actual configurations that may be emerging from its wake.

While Deleuze and Simondon share deep affinities and use core concepts in similar ways – particularly those of "individuation" and the "problematic" – their approaches are by no means reducible to each other. The approach here will therefore develop a kind of Deleuzian-Simondonian synthesis, which will involve re-reading Deleuze's, as well as Deleuze and Guattari's, work through the lens of Simondon's understanding of "individuation", as well as his concepts of "metastability" and "transindividuality". This approach will in some sense be more "Simondonian" than Deleuzian, in particular by adopting an understanding of individuation that focuses more on the emergence of what D&G would call "molar" individuals[81], though it will weave this conception together with several core concepts from *A Thousand Plateus* (ATP), in particular the concepts of assemblages, the capitalist axiomatic, mapping, and minor science.

Simondon on Individuation, Metastability, and Transindividuality

The concept of "individuation" was elaborated most extensively in the work of Simondon, which has been rediscovered as a potent source for "anti-individualist" thinking by both political theorists and philosophers in recent years (Combes, 2013; Read, 2015; Bardin, 2015). Simondon provides a conceptual framework to understand "individuals" – whether organisms, human subjects, states, or other modes of collective

[81] As Bardin explains, Deleuze tends to frame molar individuals as a kind of epiphenomenon of molecular processes, whereas Simondon accords more agency to the molar register (Bardin, 2015: 210).

organization – as dynamic *processes of individuation* rather than *substantialist* entities*,* which continuously co-evolve alongside an equally dynamic "preindividual milieu".[82] Simondon's main target here is the metaphysical doctrine of "substantialism", which he describes as the view in which "being is considered as consistent in its unity, given to itself, founded upon itself, not created, resistant to that which it is not" (Simondon, 2009: 4). In other words, substantialism *ontologically privileges* the individual as a self-given unity that persists through time, rather than understanding the individual as a "phase" in a more-than-individual process that enfolds the individual with its preindividual milieu (ibid: 5). In the history of philosophy this position is most clearly seen in the Platonic theory of essences, which posits discrete and eternal forms in which actual objects participate and from which they derive their individuality, as well as the theory of "atomism" that posits in-divisible atoms as the building blocks of all higher-order individuals. In the field of IR, substantialism can be seen at work in the tendency of neo-realists and others to reify "states" as unified agents, which brings Simondon's work in resonance with critiques of substantialism in IR like those of Patrick Jackson and Daniel Nexon (Jackson & Nexon, 1999). However, rather than simply focusing on inter-state relations, the Simondonian understanding of individuation foregrounds the flows of energy, materials, and information through which individuals at all scales (whether crystals, organisms, or societies) emerge, reproduce, and transform themselves.

In order to develop an ontology of process that unseats the privilege of the individual without thereby dissolving it a preindividual flux, Simondon introduces the

[82] While related to the more familiar concept of "autopoiesis", defined as the process through which an individual produces and reproduces itself (Maturana & Varela, 1980), individuation captures the *coming-into-being* or *emergence* of an individual that is always continuously enfolded with and open to the outside, whereas autopoiesis emphasizes self-regulation and "operational closure".

concept of “metastability”. Metastability can be understand as a state dynamically poised between the poles of stabilized identity and pure flux, which are propelled by the enfolding of preindividual tensions within the structure of the individual (Combes, 2013: 3). Though Simondon doesn’t use these terms, the notion of metastability can be considered a precursor to Prigogine and Stengers’s analysis of far-from-equilibrium dissipative structures, which must continuously consume and metabolize matter-energy to retain their dynamic structures and functions (Prigogine & Stengers, 1984). For Simondon, the *living* individual can in this sense by understood as a far-from-equilibrium dissipative structure capable of continuous individuation.[83] Whereas a true “equilibrium” would signal the “death of becoming”, metastability indicates the capacity of a system to self-organize by inventing new structures that “resolve” (though without “negating”) the preindividual tensions from which it emerges. In Simondon’s words:

> stable equilibrium, in which all potential would be actualized, would correspond to the death of any possibility of further transformation; whereas living systems, those which precisely manifest the greatest spontaneity of organization, are systems of metastable equilibrium; the discovery of a structure is indeed at the very least a provisional resolution of incompatibilities, but it is not the destruction of potentials (Simondon, 2017: 176-177).

In this sense, individuals can be understood as “provisional resolutions” of preindividual energetic tensions, and these tensions remain encapsulated within the individual as a reservoir of potential energy that makes it susceptible to further transformations in response to new events or encounters. Thus in a way comparable to Marxist HM, we can think of individuals (including socio-ecological formations) in terms of “successive stages of an individuating structuration, going from metastable state to metastable state

[83] Andrea Bardin makes the link between Simondonian metastability and Prigoginian dissipative structures very clear: “[metastability] defines a condition of equilibrium in complex systems, the stability of which can be easily broken by the intake of a little bit of energy or information and, conversely, needs a continuative and regular energetic support to counter its tendency to entropy” (Bardin, 2015: 6).

by means of successive inventions of structuration" (ibid: 169). Rather than a teleological progression through predetermined phases, this should be understood as a creative and contingent process that is nonetheless structured in its range of possibility.

Though Simondon illuminates structural similarities between processes of individuation at different levels of complexity – inorganic, biological, and psychosocial – his framework also accounts for the unique features of these different levels of system organization, rather than simply reducing them all to the same model.[84] In particular, Simondon uses the term "psycho-social individuation" (or "transindividuation") to identify the mode of individuation specific to the social domain. In essence, psycho-social individuation constitutes a threshold beyond organic individuation by "individualizing" the human organism as a subject while simultaneously producing an emergent collective that combines relations between biological, social, and technological elements. In this sense, transindividuality "is what causes [human] individuals to exist together like elements of a system comprising potentials and metastability" (quoted in Scott, 2014: 113). Simondon's concept of the transindividual paves a path between an atomistic individualism that conceives societies as merely an aggregation of already-individuated individuals, and various forms of structuralism or functionalism that dissolve the individuality of the individual into a societal holism that determines the form

[84]For example, Simondon discusses the crystal as a paradigmatic example of individuation, which proceeds through the operation he calls "transduction", defined as "an operation--physical, biological, mental, social--by which an activity propagates itself from one element to the next, within a given domain, and founds this propagation on a structuration of the domain that is realized from place to place" (Simondon, 2009: 11). A crystal, in this sense, emerges from a "super-saturated" solution rife with energetic potentials, which resolves itself through a "system-phase shift" whereby a crystalline seed triggers the propagation of a crystalline structure throughout the solution (ibid). Whereas an inorganic structure like a crystal only undergoes a single event of individuation, a living organism is characterized by a "perpetual individuation" that conserves metastability and continuously resolves problems of compatibility between itself and the milieu from which it emerges (Combes, 2013: 28). In this way, as Combes explains, we cannot claim to study "individuation in general", but are always dealing with singular cases of individuation. Still, it is possible to discover what Simondon calls "analogical operations" between such cases in different processes and scales of being (Combes, 2013: 12; see also Bardin, 2015: 58-59).

or subjectivity of the individual (e.g. certain forms of Marxism). In this way, rather than conceiving the transindividual as a matter of inter-subjective relations, which assumes relations of communication between already formed subjects, Simondon emphasizes that the transindividual must be understood in terms of a process of resolving preindividual relations of affectivity and perception that simultaneously produces both "individuals" and "collectives". As Jason Read explains, "Transindividuality is not a relation that passes through already constituted individuals…but passes through the pre-individual aspects of individuality, affects and perceptions" (Read, 2015: 135).

Whether referring to the registers of inorganic, biological, or psycho-social-technical individuation, Simondon argues that the individuals populating these different domains are conceived as resolutions of *preindividual problematic fields*, or *inventions of compatibility* between disparate orders that in this way form an "informational system"[85] (Simondon, 2009: 9-10). As Deleuze describes in his review of Simondon, individuation "needs to *resolve the problem* which disparate realities pose, by organizing a new dimension in which they form a unique whole at a higher level" (Deleuze, 2004b: 87). In other words, echoing the language of Complexity Theory, the process of individuation creates channels of communication between disparate processes that enables them to form "emergent" wholes that are irreducible to the sum of their parts. One might say that disparate processes pose *tensions* that impel "resolution" by the emergence of higher order individuals that integrate these processes. Muriel Combes gives the example of plants, which establish communication between a cosmic order (sunlight) and a

[85] Simondon reworks the concept of "information" to refer not simply to a transfer of significance between a sender and receiver, but rather the process through which both sender and receiver co-individuate. In his words, "it is the signification that will emerge when an operation of individuation will discover the dimension according to which two disparate realities may become a system" (ibid).

molecular order (mineral salts and oxygen) (Combes, 2013: 3). Similarly, we could think of social formations as ever more complex (and more often than not "imperialist") integrations or "inventions of compatibility" between disparate entities and processes – between humans and their ecological milieus, between disparate forms of psycho-social individuation, between humans and technical systems, between disparate technical assemblages, and between humans and the universe at large (Chabot, 2013: 132-133).[86] In this sense, Simondon is clearly a thinker of synthesis, and his work has deep salience for us today as we strive to invent new "relations of compatibility" between disparate psycho-social, technological, and ecological processes of individuation at all scales from the microbial to the planetary, bringing our transindividual collectives (simultaneously human, technical, and ecological) through the present crisis towards the building of new transindividual worlds (ibid: 19-20).

While Simondon's philosophy beautifully illustrates how individuals of all kinds can be understood as metastable resolutions of a preindividual problematic, it only provides a limited and in some sense intuitive account of the concept of a "problematic", at least in his writings that have so far been translated into English. But another better-known philosopher would later take up his concepts and expand on them by articulating them as part of a philosophical system of arguably unrivalled complexity. Thus to deepen

[86] It is worth emphasizing that Simondon does not simply affirm integration/synthesis as an inherent good. It is rather, echoing Deleuze, a question of the sustainability of a particular mode of integration as well as the quality of the affirmations it enables. While such imperial "solutions" have been the norm throughout history to the present day, these have also failed to create sustainable political-economic orders, seen in the collapse of Empires and return to more autonomous communities and polities throughout history (Tainter, 1988). We can say this is largely due to the unresolved tensions and violence (towards both humans and non-humans) that are historically constitutive of these orders, which are like virtual fault lines that become actual in the form of social unrest, terrorism, civil war, and ecological degradation. The situation is clearly no different with the contemporary neoliberal-capitalist world system. Thus the challenge of forging a "planetary civilization" or world-assemblage that enables a *metastable coexistence of disparate yet partially integrated modes of collective individuation* – what Warren Wagar described as "the world in a state of optimal integration" (Wagar, 1967: 15) – remains unresolved, and is arguably the ultimate (virtual) task demanding planetary-scale resolution in the 21st century.

our grasp of this ontological understanding of the "problematic", we will now turn to the work of Deleuze.

The Deleuzian Problematic

Deleuze's work can reasonably be understood as a speculative extension and deepening of Simondon's philosophy of individuation, which borrows many concepts from the latter while broadening their philosophical significance. The concept of the "problematic" is one of the most important, which finds its most extensive treatment in Deleuze's metaphysical treatise *Difference and Repetition*. While Deleuze's deployment of the term is closest to Simondon's usage, the concept of the problematic has a longer lineage in French philosophy, forming a key concept for the philosopher of science Gaston Bachelard, as well as the work of Althusser and Foucault (Maniglier, 2012). While these other thinkers understood the problematic as an *epistemological* concept, or a way to understand the field of problems and concepts in which a particular thinker is engaged, Deleuze elaborates an *ontological* understanding of the problematic, where Being is itself the repository of "problems" from which particular processes and systems emerge as "solutions". As Deleuze writes, "problems do not exist only in our heads but occur here and there in the production of an actual historical world" (Deleuze, 2004a: 239).

Following Simondon's lead in conceiving the process of individuation as a process of resolving preindividual problematic fields, Deleuze will go further in elaborating the abstract structure of a problematic field. He defines the latter in terms of "multiplicities or complexes of relations and corresponding singularities", or "a system of differential relations between genetic elements", which structures the "possibility space"[87] for specific processes of individuation (Deleuze, 2004a: 203, 229). A problematic or multiplicity for Deleuze refers to a *multi-dimensional complex of reciprocally determining processes* that "have no need of unity to form a system", and which undergo qualitative changes in kind as they add and subtract dimensions (ibid: 230). Deleuze will say that a problematic is *intensive*, in the sense that it is composed by a field of differential relations between disparate processes that are subject to *qualitative transformations* when they pass critical thresholds of quantitative change (Delanda, 2005: 18). Intensive differences for Deleuze are the engine of individuation processes, the tensions structuring a problematic that must be "resolved" in order to attain a (provisional) form of (metastable) individuality. In his words: "everything which happens and everything which appears is correlated with orders of differences: differences of level, temperature, pressure, tension, potential, differences of intensity" (Deleuze, 2004a: 280). To delineate the dimensions of a problematic, requires determining the most relevant processes and their rates of change that structure a specific system or field of becoming (its "degrees of freedom"), mapping their relations and feedbacks, and then integrating them through a kind of "differential calculus" (Delanda, 2005: 5).[88]

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[87] Those who study Deleuze will recognize that the notion of "possibility" here jars with Deleuze's understanding of virtuality, as it signifies a delimited field of representation rather than the "real" genetic conditions that produce the actual. However, we can usefully follow Delanda in using the concept of "possibility spaces" from dynamical systems theory to help us cognitively map the contours of the virtual, so long as we don't confuse the virtual itself with such spaces.

[88] In one sense Deleuze's reference to differential calculus can be understood metaphorically as a way to conceptualize the operation of individuation as an integration of differential relations. However, as Deleuze argues in *Difference and Repetition*: "each engendered domain…possesses its own calculus…there is no metaphor here…there is a *mathesis universalis* corresponding to the universality of the dialectic." (Deleuze, 2004a, 229). In other words, for Deleuze, just as the differential calculus is a tool for calculating trajectories (i.e. "solutions") by integrating linked rates of change, so can various processes of individuation (inorganic, biological, and social) be thought of as actual solutions to a (virtual) differential calculus. While there is thus an intrinsic connection between his understanding of individuation and the work of dynamic systems theorists and complexity modelers, Deleuze is more interested in dynamic real-world operations rather than idealized models that allow for neat quantitative solutions. As Protevi and Bonta write, "there are no exact quantitative solutions to the problems of minor science. Instead, they're resolved by 'real life operations'"

Manuel Delanda elaborates these Deleuzian concepts using the terms of dynamic systems theory. For systems theorists, the method of linking rates of change through differential calculus is how "phase spaces", or multi-dimensional spaces that model the possible trajectories and behaviors of a system, are constructed. As Delanda explains, each dimension of a phase space constitutes a degree of freedom for the system or field of intersecting processes, and these interaction can be modeled by integrating their linked rates of change and simulating their possible trajectories. Dimensions can be distinguished by referring to "control parameters", which are (relatively) external conditions (e.g. climate) that shape/constrain the evolution of individuating systems, and "state variables", which refer to the internal processes and tensions that constitute a system (e.g. in the case of an ecosystem: rates of population growth for different species, nutrient availability) (Delanda, 2016: 119).[89] One of the keys to understanding a problematic, and constructing a representational phase space, is to understand the "dependency relations" between its multiple dimensions. As Delanda explains:

> we need to establish *relations of dependency* in the way variables (and parameters) change…so that the combination of values for each variable defining a given point is coherent relative to the dependency relations (Delanda, 2016: 119-120).

In other words, the values of the key parameters and state variables all move together, with the phase space containing all the viable combinations of their values and movements. Yet they do not move together in a uniform or quantitatively determinate

(Protevi & Bonta, 2004: 24-25). For example, they note how Lansing (1991) models the problem of irrigation in Bali, which involves multiple dimensions in geomorphology, agriculture, irrigation, ownership patterns, and labor availability. While computer simulations can help illuminate the complexity of the problem, it cannot provide an exact solution. Rather, it can only be "resolved" through trial-and-error experimentation on the ground, which itself could be thought of as an operation of individuation (or collective psycho-social individuation) (ibid).

[89] I hesitate to use this distinction, since the term control parameter typically evokes conditions that cannot be affected by the system under study, while the political-economic systems we're interested in are obviously having quite an impact on their environmental parameters. But it is at least useful for indicating the relative distinctions between internal and external dimensions of a system under study, though we must emphasize that they are all reciprocally determining and change collectively, rather than control parameters remaining constant.

way (i.e. in the way simulated by computational dynamic system models), with some relations and feedbacks being tighter or looser than others.

One of the key features of phase spaces is the distribution of "singularities", which refer to points in phase space that "attract" the trajectory of a system, like gravitational forces that structure the movements of celestial bodies. Hence they are often referred to as "attractors" by complexity theorists, which constitute "zones of stability" that maintain a system within a specific bandwidth of behaviors and parametric values via negative feedback mechanisms (Delanda, 2016: 120). In Delanda's words, attractors "pin down trajectories to a small set of states (coherent combinations of the values for the variables) and do not let them escape" (ibid). Attractors are linked together by "bifurcations", or abrupt transitions in the tendencies of physical processes, which can involve a shift from one pre-existing attractor to another (which Protevi and Bonta refer to, following Deleuze and Guattari, as a "relative deterritorialization"), or a more radical shift that creates a new distribution of attractors and bifurcations for the individual in question (an "absolute deterritorialization") (Protevi & Bonta, 2004: 20). For example, in the history of earth's climate the transitions between ice ages and "interglacial" periods can be modeled as a series of critical transitions between glacial and interglacial attractors (called "Milankovich cycles"), while the "problematic" of climate is determined by the differential relations between solar radiation, surface albedo, the radiative forcing of the earth's atmosphere, and the eccentricity of earth's orbit (among other variables and parameters) (Scheffer, 2009).[90]

[90] While this is not important for the purposes of my dissertation, it is worth noting that this understanding of all material-energetic processes (including those of climate and the earth system) as individuating resolutions of a problematic can be read in a "panpsychist" way. In other words, these are not simply blind and mechanical physical forces, but are rather responses to affective tensions. Thus we can speculate that the resolution of potential energy in physical systems has a proto-experiential/sensuous/affective dimension that guides it, just as humans are guided to

As Deleuze claims, problematic multiplicities constitute a "dimension of objectivity" that he will describe as "virtual", or "real without being actual, ideal without being abstract" (Deleuze, 2004a: 260). The important thing for our purposes is that the virtual constitutes a dimension of the real that is not *empirical* in the sense of referring to actualized and perceivable entities, but is rather the real "generative ground" from which actual entities emerge as "solutions" and which continuously "guides" and constrains their individuations. In Deleuze's words, "the virtual possesses the reality of a task to be performed or a problem to be solved" (ibid: 264). Delanda's reading of the virtual conceives it in the model of phase spaces – as a landscape composed of linked singularities/attractors and bifurcations between them, which guides the individuation of actual bodies (Delanda, 2006). I will for the most part adopt this reading, though it is also necessary to emphasize Deleuze's description of the virtual as a "problem to be solved". This can be made compatible with Delanda's (as well as Protevi & Bonta's) readings if we understand that processes of individuation are not only guided/constrained by the virtual, but are also simultaneously efforts to *modify* the structure of the virtual. In this sense, there is a dynamic though asymmetrical relation between the virtual and actual, as the process of actualization reconfigures the field of differential relations and singularities that constitute the virtual, which in turn reconfigures the possibility space of actualization.[91] Deleuze describes this movement with the term "counter-actualization"

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resolve our own (more complex) experiences of tension. Would this matter for our analysis of and response to the planetary problematic? Perhaps…

[91] It is worth considering briefly considering controversies regarding the ontological status of the virtual. There is no doubt that there is a speculative element to positing its existence as a real dimension that shapes, constrains, and impels the individuation of actual entities in the world. Hence many complexity theorists like Byrne and Callaghan reject Delanda and Deleuze's ontological interpretation of phase space, attractors, and bifurcations, instead claiming that they are merely useful analytical tools that can be used as metaphors to provide insight into social dynamics (Byrne & Callaghan, 2013). Does it matter whether we use phase space concepts metaphorically or posit them as (necessarily imperfect) representations of the virtual? For the purposes of the analysis undertaken in this dissertation, not really. But it is worth noting that the concept of the virtual as the repository of dynamic "ideational multiplicities" that are

(Deleuze, 1990: 150), or in John Protevi's words, "changing the virtual conditions for future actualization" (Protevi, 2013: 151). For example, we could understand the human impact on the climate system as an instance of "counter-actualization" that will potentially create a new distribution of attractors and bifurcations that will reshape the earth system's evolution for eons to come.[92]

We can say that the virtual poses a problem both in the sense that it determines the range of possible ways of being an individual of a particular type (e.g. solutions to the problem of being a human, or a nation-state, or a world-system, etc) and in that the process of individuation is always a (more-or-less successful) attempt to modify the virtual in order to widen the possibility space of being a particularly kind of individual, or even to become a qualitatively different kind of individual. We could also say that counter-actualization is the process by which a virtual problem is truly "resolved" (or at least transformed), since it widens the structure of the possibility space that had previously constrained the individual within a particular range of behaviors and tendencies, thereby enhancing its degrees of freedom. This is key since, as Deleuze emphasizes, the process of individuation (at least in the psycho-social realm) is often plagued by the existence of "false problems", or ways of articulating a problem that fail to grasp its generative ground (i.e. its "roots"). As a result, they fail to produce

immanent to the actual is not just the crazed invention of a speculative thinker; they respond systematically to real metaphysical problems regarding essences and the stability of forms, problems which continue to preoccupy both analytic and continental philosophers. Deleuze's ontology of the virtual is merely one solution, but it is remarkable both for its analytic rigor as well as its poetic evocativeness, which goes beyond the world of scientific rationalism to express the archetypal world of myth – the world of changeless patterns behind the actual world of temporalized events.

[92] Indeed, as David Grinspoon explains (though without Deleuzian terms), this is in many ways what fossil capitalism's dissipative splurge has done: counter-actualize the phase space of the earth system, such that rather than oscillating between a glacial and interglacial regime, the earth is now likely to experience an extended ice-free state for at least millions of years. Negative feedbacks over time may return it to something like its previous pattern, though the likelihood is that current processes will reverberate for eons to great effect on the earth system's evolution (Grinspoon, 2016: 166).

"solutions" that actually resolve the tensions fuelling the problem and thereby propelling the individual (whether an individual human or collective) to change (Deleuze, 2004a: 259). For example, contemporary diagnoses of "depression" that frame it as simply an individual or neurochemical problem fail to get at the root of the problem, and thus have a false or inadequate articulation of the problematic which fails to produce lasting solutions (Hari, 2018). The same can be said for demagogues who simplify the ills of society to justify authoritarian and sometimes barbaric solutions – i.e. the "Jewish problem" and the "final solution" in Nazi Germany (Deleuze, 2004a: 259), or the "immigration problem" in contemporary nation-states.

While Deleuze's language in describing a problematic is abstract, combining insights from continental epistemology and Riehmannian geometry, the kind of abstract and dynamic structure it articulates can be understood intuitively. Processes of evolution in both biological and human history are often understood as successive responses to problems that are simultaneously timeless and historically contingent – problems of harnessing matter and energy to actualize ever more complex and differentiated forms.[93] Thus Deleuze will say that an "organism is nothing if not the solution to a problem, as are each of its differenciated organs, such as the eye [that] solves a light 'problem'" (Deleuze, 2004a: 263). Planetary scientist David Grinspoon echoes this insight when he claims that "natural selection is a ceaseless and thorough trial-and-error search for survival solutions" (Grinspoon, 2016: 280), though Deleuze would emphasize that

[93] The Deleuzian problematic captures this combined sense of timelessness and historical contingency, as the "problems" confronted by all individuating entities are in some sense universal though also singular depending on the historical/evolutionary context. Hence Deleuze will say that "the problem or the Idea is a concrete singularity no less than a true universal" (Deleuze, 2004a: 202). In a more down-to-earth statement of this singularity-universality relation, in the context of agriculture, agroecologist Mike Madison writes: "All agriculture is local, and the particular details of my operation might not be applicable elsewhere, but the basic variables are universal, and every farmer has to solve the same set of problems in whatever way works in his or her circumstances" (Madison, 2018).

evolution is at least as much a matter of aesthetic creation and expression as survival (Deleuze, 2004a: 263). Similarly, sociohistorical evolution has been described as a process of posing and resolving problems – problems of cooperation, producing and distributing surplus, regulating violence, enforcing social codes, managing relations with other societies, and creating new ways of life – and can thus be understood as an "exploration of a space of possibilities" that is structurally constrained yet potentially inexhaustible (Stewart, 2014; Deudney, 2000; Althusser, 1969). Because a virtual problematic is in some sense trans-historical (though no less dynamic for that), we tend to see recurrent solutions that could be understood as "attractors" (e.g. imperial states, agrarian communities, city-states, nomadic tribes) and patterns (e.g. of war-making, trade, conquest, state-formation, and collapse) over the course of history, though these often repeat with a difference (Tainter, 1988). As the well-worn aphorism (often attributed to Mark Twain) goes: "history doesn't repeat itself, but it often rhymes". From a Deleuzian perspective, we would say that the virtual problematic that structures the realm of psycho-social individuation is what gives history this patterning, though it is not a fixed structure: counter-actualization is always possible, though (to recycle another cliché) failure to learn from history will doom us to repetition (always with a difference).

Complexity Theory Interlude

The work of Manuel Delanda and John Protevi is exemplary in illustrating the overlaps between Deleuzian philosophy and Complexity Theory (CT), since both were highly influenced by advances in mathematics that led to nonlinear dynamics and chaos theory. But CT (as a broad umbrella term) has also continued to evolve since Deleuze's time, and it can therefore help clarify and deepen our understanding of certain concepts that are intuited but not explored in Deleuze's (or Deleuze and Guattari's) work. In particular, I will focus on the concepts of catastrophic bifurcations and resilience, which are important to the analysis undertaken in chapter six.

Catastrophic Bifurcations

First, we have seen how Deleuze's concept of the virtual can be mapped on to the concept of phase space from CT, which constructs a landscape of attractors and bifurcations that structure the possible behaviors, tendencies, and trajectories that are available to a system. Here it is worth exploring the concept of "bifurcation" in more detail, since it is crucial for understanding the 21st century planetary conjuncture. As we have seen, a bifurcation typically refers to a "phase-shift" in which quantitative changes in one or multiple critical parameters give rise to a qualitative reorganization of a system, which can be represented as a shift from one attractor basin to another. As Marten Scheffer explains, there are many different forms a bifurcation can take, which can be described by complex mathematical formalisms. For our purposes, it is worth distinguishing between "non-catastrophic" and "catastrophic" bifurcations, each of which in turn has multiple sub-types. Non-catastrophic bifurcations occur when a system reaches a point at which one or several of its key parameters or state variables begins to change before reaching a relatively stable point; for example, a population of predators may reach a point at which it begins to rapidly decline (e.g. in response to food source depletion) before reaching a new stable state (Scheffer, 2009: 16). Such shifts are more *continuous* and *reversible*, in the sense that a subsequent increase in the food source to its previous levels will lead to a corresponding population increase back to where it was before the decline (ibid). In a *catastrophic* bifurcation, on the other hand, there is a more *discontinuous rupture* that cannot be reversed by simply reversing the change in the critical parameter. Instead of a relatively smooth transition to a new point of stability, the phase space is said to "fold" in a way that creates at least two alternative attractors that are separated by an unstable region. The system exhibits "hysteresis", in which a qualitative rearrangement of feedbacks maintains the system in an alternative attractor even if a particular parameter returns to its previous state (ibid: 20). Marten Scheffer describes a catastrophic bifurcation as follows:

> When the system is in a state on the upper branch of the folded curve, it cannot pass to the lower branch smoothly. Instead, when conditions change sufficiently to pass the threshold…a 'catastrophic' transition to the lower branch occurs…Such bifurcations are characterized by the fact that an infinitesimally small change in a control parameter…can invoke a large change in the state of the system if it crosses the bifurcation (ibid: 18).

While the difference from non-catastrophic bifurcations is subtle, the key difference is that catastrophic bifurcations involve a *rupture* in the phase space of the system – what is called a "catastrophe fold" – that creates at least two alternative attractors separated by a chaotic phase-transition. A non-catastrophic bifurcation, on the other hand, involves a less dramatic change in the values of key parameters and does not qualitatively reorganize the feedbacks defining a system, and it can therefore be reversed more easily (i.e. it doesn't exhibit hysteresis). Another way to put the point is to say that a catastrophic bifurcation involves a more radical rupture in the "topological cohesion" of a system's internal feedbacks, such that it leads to a "symmetry-breaking cascade" that reorganizes the system via a novel arrangement of differential relations and feedbacks (Delanda, 2005: 10-11).[94]

Scheffer also shows that catastrophic bifurcations can be divided into different types, with a catastrophe fold distinguishable from a transition event often referred to as "self-organized criticality". In these latter events, as Scheffer explains: "a 'tension' or 'vulnerability' builds up" during a "quiescent state" and is eventually released once a continuously changing variable or parameter reaches a critical point (Scheffer, 2009: 59). Earthquakes, forest fires, and sand-pile avalanches are classic models of such events. While they are comparable to catastrophe folds, the latter focus on the interactions between a few variables in a relatively "homogeneous system", whereas self-organized criticality focuses on "spatially explicit" and "heterogeneous systems" in which small local events can trigger a chain reaction (ibid: 61-62). In this sense, catastrophe folds refer to catastrophic bifurcations in more hierarchically structured systems (what Deleuze and Guattari would call, as I'll discuss below, "arboreal" assemblages), whereas self-organized criticality events are catastrophic bifurcations in more horizontally networked systems (which Deleuze and Guattari would call "rhizomatic" assemblages).

It is important to emphasize that these mathematical models of catastrophic bifurcations are in some sense "ideal types" that are not always easy to map directly onto empirical reality. There may be a spectrum of gradations between catastrophic and non-catastrophic bifurcations, as well as between catastrophe folds and self-organized

[94] As a (speculative) example from history, consider the difference between the *irreversible* collapse of the Western Roman Empire, and the (at least in some respects) *reversible* collapse of feudalism in the wake of the black death. This follows Perry Anderson's thesis of the difference between the emergence of feudalism and capitalism, with the former involving "a 'catastrophic', not 'cumulative' passage between two modes of production (whose structure thus necessarily diverged *in toto* from the transition between feudalism and capitalism" (Anderson, 1974: 137). The metaphor is not entirely appropriate, since the "collapse" of feudalism led to a reorganization of social relations (in particular the empowerment of peasants vis-à-vis the feudal lords) that facilitated the gradual rise of capitalism. But the key difference is that the latter was followed by a relatively rapid restoration of political-economic complexity and integration, whereas the collapse of the Western Roman Empire was followed by a prolonged period of fragmentation.

criticality, in actual systems and processes. But from a Deleuzian perspective, we would say that the mathematics that describe such bifurcations are the *virtual* (or ideal) counterparts of *actual* bifurcations in the empirical world. In other words, following Delanda, they could be considered "virtual diagrams" that are shared by very different systems and processes at different scales (from the molecular to the biological and social) (Delanda, 2000: 58-59). The discovery by contemporary complexity theorists of similar dynamics of self-organized criticality, phase transitions, and scaling laws in physical, biological and social systems lends credence to Deleuze's hypothesis of virtual singularities that structure these diverse domains (Mitchell, 2011; Miller, 2015; West, 2017), though this doesn't vitiate the need to study these empirical domains through refined epistemic tools unique to each.

Resilience

While the language of phase space, attractors and bifurcations remained the preserve of mathematics for a time, it has become increasingly common across disciplines with the rise of "resilience theory" over the past couple of decades. As we saw in chapter two, resilience has become an increasingly prominent buzzword among governmental agencies, though it has its origins in ecology. C.S. Holling defines resilience as "a measure of the ability of…systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling, 1973: 17). Building on while modestly breaking from this understanding, Carl Folke and colleagues emphasize "the degree to which a complex adaptive system is capable of self-organization…and the degree to which the system can build and increase the capacity for learning and adaptation" (Folke et al, 2010). These two definitions indicate a (productive) ambiguity at the heart of resilience theory, since some definitions emphasize the capacity of systems *to absorb shocks without undermining their structure and functionality*, while others emphasize the ability of systems *to adapt and transform themselves* in response to various events. In the first form, resilience can be represented by the size of a system's attractor basin: the larger the attractor, the more difficult it is for external perturbations to push it towards an alternative attractor (Scheffer, 2009: 101). In the second, resilience refers to a system's "adaptive capacity", or the degree to which it is capable of learning and reorganization. In Scheffer's words, this view of resilience emphasizes "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (ibid: 103). Brian Walker and colleagues go even further in emphasizing the link between resilience and "transformability", defined as

> the capacity to create untried beginnings from which *to evolve a new way of living when existing ecological, economic, or social structures become untenable*…[by] defining and creating new stability landscapes by introducing new components and ways of making a living, thereby changing the state variables, and often the scale, that define the system (Folke et al, 2010: 5, 7; emphasis added).

We might therefore frame understandings of resilience along a continuum between preservationist, adaptive, and transformationist approaches (Davidson et al, 2016), which is why the term is often so ambiguous and liable to both conservative and radical readings. Either it refers to a system's capacity to remain within a pre-existing basin of attraction through negative feedback mechanisms (which is often how security agencies interpret it) (Coaffee, 2010), to learn and adapt in order to reorganize while still retaining its basic structure and "identity" (more-or-less how it is used by neoliberal development agencies like the World Bank) (World Bank, 2012), or to transform itself through the creation of "untried beginnings" (its understanding in grassroots sustainability initiatives like "Transition Towns") (Hopkins, 2008). Of course this raises challenging questions about what we mean by "identity", what it means to preserve a systems core identity, and what would entail a transformation in this identity.[95] I will return to such questions when discussing the future of the capitalist world-system, but for now it is simply worth emphasizing that such a broad spectrum of approaches to resilience exists, and that it cannot therefore be confined to one particular (neoliberal or military) perspective (as Foucauldian critics tend to do).

From a Deleuzian perspective, we would say that resilience is a real but *virtual* property of a system – a "*collection of latent properties* that can be called upon during an acute shock" (Patel & Nosal, 2016: 5). In other words, while it cannot be directly observed or measured, it is a real attribute that *expresses* itself in the way particular individuals respond to crises and perturbations. Understanding resilience in this way can show us why it is valuable to include something like the virtual in our ontologies of world politics. As Marten Scheffer explains, slow changes in environmental conditions can over time "shrink" the attractor basin of a particular system while creating new attractors and points of bifurcation, though the system won't undergo a critical transition unless there is a major perturbation of the system:

> If we were to monitor the state of the system, we would not see much change at all. Nothing would reveal the fundamental changes in the stability landscape. If conditions change even more, the basin of attraction around the equilibrium in

[95] In the view of system theorists Graeme Cumming and John Collier: "system identity resides in the continued presence, in both space and time, of key components and key relationships" (Cumming & Collier, 2005: 3). They note that this always involves interpretation and evaluation to determine what is internal to a system, what is external, and which relations and feedbacks are the tightest and most significant. Thus they would likely agree with Deleuze that "identity" is less an ontological property of individuals (which can never be clearly distinguished from their preindividual milieus) and more an epistemological category that is relative to an observer.

> which the system rests becomes very small and eventually disappears… implying an inevitable catastrophic transition to the alternative state (Scheffer, 2009: 21-22).

In this sense, while changes in the actual would appear to be gradual and minor, major transformations can nonetheless be underway in the domain of the virtual. This is especially critical today in thinking about the resilience of global capitalism and the possible imminence of a catastrophic bifurcation. Without understanding something like the virtual counterpart of an actual system (which would enable us to visualize its landscape of attractors and bifurcations) and the numerous intensive differences that compose it, we may be led into continuationist complacency (due to superficial appearances of stability). This of course does not mean that we can directly map or perceive the virtual, or that there is any sure fire method of anticipating catastrophic bifurcations (though there are signs to look for, as Scheffer discusses[96]). We can only be detectives in this sense, using a combination of theory, history, intuition, and imagination alongside the most rigorous possible analyses of data and trends in key parameters and state variables (which I'll discuss below as components of a Deleuzo-Guattarian "method" of minor scientific mapping).

Deleuze and Guattari

[96] Scheffer identifies four possible signs of an approaching bifurcation that may be relevant for political-economic analysis: 1) critical slowing down, or slower recovery of a system from perturbations; 2) increasing variance in fluctuations (as system slows in returning to equilibrium, random perturbations will push it around, looking like a random walk); 3) "flickering", in which stochastic forcing throws a system back and forth between attractors (seen in the thermo-haline circulation system flipping on and off before switching on permanently); and 4) increased spatial coherence in which units of a system becoming increasingly coupled (e.g. in financial markets) (Scheffer, 2009).

To complete the conceptual repertoire of Deleuzian Planetary Assemblage Theory, I will now turn to key concepts drawn from the co-authored work of Deleuze and Guattari (henceforth D&G). There is much debate concerning the relation between Deleuze's early work and the latter work with Guattari, with some emphasizing deep philosophical continuities and others important discontinuities (Somers-Hall et al, 2018). For the purposes of my analysis I will emphasize the philosophical continuities between the two, though it is useful to turn to this latter work for insight into how Deleuze's early philosophy can be applied more explicitly to problems of political-economic analysis and praxis. Rather than trying to explicate and deploy D&G's conceptual system as a whole, which risks locking oneself into a self-contained conceptual universe (Brassier, 2018), I will instead use their work as a tool-kit from which to select concepts that are most useful for the purposes of developing a multi-dimensional analysis of (and response to) the planetary crisis convergence. To this end I'll focus on the concepts of assemblages, the capitalist axiomatic, mapping, and minor science.

Assemblages

Assemblages refer to emergent configurations combining human and non-human components, which could include institutions, markets, infrastructures, technologies, flows of affect, resource flows, and ecological webs.[97] While the term "assemblage" can to some extent be understood through the more familiar term "system", the latter term is often associated with the Hegelian understanding of "totality", which conceives systems

[97] In contrast, the variant of assemblage thinking inspired by "Actor Network Theory" (ANT) focuses on empirically tracing local connections between hybrid agencies in diverse local contexts, rather than illuminating emergent structures and their "possibility spaces". Whereas ANT could be considered a kind of empiricism, assemblage theory in its Deleuzian/Delandian variant is closer to "critical realism" in its emphasis on real but unobservable structures.

through organic metaphors of wholeness and homeostasis that functionally subordinate the parts to the reproduction of a self-consistent whole.[98] In contrast, as Delanda explains, this "organic" understanding of a system only refers to one pole on a continuum of systematicity – referring to the most stratified or hierarchical systems. Assemblages, on the other hand, can refer to looser configurations in which the parts are reciprocally co-constituting but retain their relative autonomy from the whole, which Delanda often refers to as interlocking "meshworks" that can continuously transform themselves without losing their consistency (Delanda, 2016). Whereas a biological organism provides the clearest example of a hierarchical or "arboreal" assemblage, an ecosystem exemplifies what D&G would call a *rhizomatic* assemblage, which integrates heterogeneous elements without imposing a fixed structure. Delanda frames this difference through the notion of "relations of interiority" vs. "relations of exteriority": the parts of an assemblage retain relations of exteriority in the sense that the identity of the parts retain relative autonomy from the whole and can take on new properties through novel linkages with other components, whereas relations of interiority imply that the identity of the components is subordinate to the whole of which they are a part (Delanda, 2006: 10-11). Thus the term assemblage helps us understand emergent configurations between the poles of hierarchical order and chaos, rather than assuming that such wholes – whether "human" individuals, nation-states, world-systems, or the biosphere – can be understood solely through the lens of self-regulating cybernetic machines or autopoietic

[98] This Hegelian conception is also referred to as an "expressive totality", which has been criticized by poststructuralists like Derrida for assuming a "structural center" from which the rest of a systemic configuration can be derived as the unfolding of an original seed (Edwards, 2010). There are other ways in which the concept of totality has been used, included the Althusserian notion of "complex totality" in which diverse elements are articulated without assuming a structural center (Althusser, 1967). While the more Althusserian conception is closer to D&G's approach, it remains overly functionalist and lacks the concepts to capture the dynamism of assemblages and their couplings that form social formations.

loops, instead emphasizing their openness and permeability, fragility, and capacity to become-other through novel couplings.

Whether they fall more on the arboreal or rhizomatic side of the continuum, assemblages can be understood (like systems) as emergent wholes at different scales with their own tendencies, behaviors, and capacities to affect and be affected by other processes and assemblages (ibid: 18). Thus they have each have an emergent structure, in the sense of a "possibility space" composed of attractors and bifurcations between them, though this constitutes an amorphous structure that is subject to continuous (or discontinuous) shifts as events and encounters in the world unfold (ibid: 30). The possibility space of each assemblage emerges from the reciprocally determining relations between its components, while the relations between assemblages can in turn create higher-order assemblages with their own emergent properties and capacities. Delanda's multi-scalar approach to assemblage theory thus resonates with the concept of "panarchy" from ecology, which understands ecosystems in terms of a nested multi-scalar structure of ecological processes, with processes at higher-levels (e.g. the global climate system) emerging from and simultaneously constraining (typically faster) processes at smaller scales (e.g. regional biomes, local ecosystems, and micro-niches) (Holling & Gunderson, 2002; Gotts, 2007). However, assemblage theory emphasizes that these nested ecosystems must be understood as *socio-ecological* assemblages, since we cannot divorce these ecological processes from the political-economic practices, technologies, and structures of power that "internalize" and transform them at multiple scales (Moore, 2015). And rather than sharply delimiting between assemblages at different scales or positing a one-way causal hierarchy in which higher orders determine the lower ones, this vision instead follows David Byrne and Gillian Callaghan's vision of "nested but interpenetrating systems with causal powers running in all directions" (Byrne & Callaghan, 2013: 45).

The Capitalist Axiomatic

The framework of assemblage thinking provides D&G with the means to integrate certain insights from Marxist HM without succumbing to the Hegelian temptation of totalization. The Hegelian dialectical heritage, transformed yet still at work in Marx's *Capital* and later HM developments, bequeaths an understanding of social systems as contradictory totalities, whose evolution is driven by these contradictions until the moment of "negation" in a higher synthesis (the Prussian state for Hegel, and communism for Marx). For D&G, in contrast, it is not only misleading to speak of "social" systems (which are rather complex bio-social-technical-ecological assemblages) but also to speak in terms of "totalities", which would assume an organizing center from which components of the capitalist system are functionally subordinated to the reproduction of the whole (Delanda, 2006). However, in contrast to Deleuzians like Delanda and others inspired by Bruno Latour who think this vitiates the need for concepts like "capitalism" and the possibility of systematic global critique (rather than infinite description and local intervention) (Delanda, 2006; Latour, 2007; Acuto & Curtis, 2013), D&G clearly affirm the possibility of developing a systematic theory and critique of global capitalism without thereby rendering it as a totality.

Rather than an organic totality that subsumes social reproduction on a planetary scale, D&G conceive capitalism as an "axiomatic" that supervenes on a multiplicity of bio-social-ecological-technological-political assemblages.[99] What D&G understand as the uniqueness of capitalism and the core of Marx's insight is its immense power of "deterritorialization", which can also be described as a process of "abstraction" though which sedimented forms are loosened and new flows and patterns begin to emerge, which is born at the moment of conjunction between deterritorialized flows of labor and money. The term "axiomatic" highlights the way that capitalism converts specific elements, systems and qualities into abstract quantities – thus integrating them into a global market system of generalized equivalence and exchange – whereas "codes" are relative to specific territories and express specific relations between qualified elements (Deleuze & Guattari, 2004*:* 501). The peculiarly abstract nature of the axiomatic enables it to conjugate with the most varied kinds of states, even ostensibly "non-capitalist" states (e.g. China, Venezuela), by adapting to their local context through new axioms and integrating it with the world market. As D&G describe:

> there is but one centered world market, the capitalist one, in which even the so-called socialist countries participate…But it would be wrong to confuse isomorphy with homogeneity…isomorphy allows, and even incites, a great heterogeneity among States (ibid: 502-503).

D&G in this way follow world-system theorists like Wallerstein and Samir Amin in positing the capitalist axiomatic as something like a global attractor with diverse local expressions, though this forms something more like a "world-assemblage" rather than a "world-system" as traditionally understood.

While D&G thus consider themselves "Marxists" in the sense that systematic analysis of and struggle against the globalizing tendencies of capitalism is a prerequisite for human (and non-human) emancipation, they are clearly "post-Marxist" in that they

[99] One of the hallmarks of assemblage thinking is its tendency to attach many words via hyphens.

affirm the need for diverse “minoritarian” struggles (beyond simply “class” struggle), break with Marx’s dialectical understanding of the structure and evolution of capital, and analyze a diverse array of assemblages that subtend and/or interpenetrate with processes of capital accumulation without being subsumed by them.[100] In this they are arguably closest to Bob Jessop’s systems theoretical reinterpretation of Marx that draws on Niklas Luhmann, which understands capitalism as “ecologically dominant” in its relation to other social subsystems, but conceives this as a contingently actualized (and always reversible) rather than structurally necessary relation (Jessop, 2000). While D&G are ambiguous on the problem of counter-hegemonic struggle[101], where they differ from most Marxists is in their emphasis on affirmation and experimentation, rather than negative critique. Because they view “societies” as open-ended bio-social-technical-ecological assemblages that are loosely integrated (though without being fully subsumed) by the global capitalist axiomatic (Protevi, 2013), there is more scope within their framework for experimenting with alternative institutional and sociotechnical configurations within capitalism that can disrupt its dominant trajectories.[102] Marxists like Slavoj Zizek and Benjamin Noys see this as problematic, since D&G appear to deny the possibility of any

[100] We might say that this weaves a path between the “methodological pluralism” of Weberians and the “holism” of Marxism, instead emphasizing the need for a “heterogenesis” between interpenetrating yet relatively autonomous processes in the socioeconomic, ecological, and technological domains, which cannot be adequately understood in separation yet no more can be understood through a single evolutionary logic.

[101] This is because they at times appear to valorize minoritarian struggles for expressive difference, or the ephemeral “becomings-revolutionary” of individual subjects, while saying little about the problem of “molar” transformation (i.e. the transformation of large-scale political structures). While this is the case for many of the dichotomies they pose – in which the nomad, rhizome, and war machine appear to be celebrated against the stratifying forces of the state and arboreal thought – it is always necessary to bear in mind their repeated caveat that there is only ever mixtures between the two poles. Thus the point is not to affirm micropolitics and minoritarian struggles while denigrating counter-hegemonic struggle on the molar level, but rather to understand their interpenetration and the insufficiency of struggle at either pole alone.

[102] As Eugene Holland explains, the requirement of a radical systemic break that Jameson posits is only necessary when you conceive of a society or mode of production as a total system in the first place. If society is actually composed of heterogeneous elements that don’t form a total system, then a radical systemic break may not be necessary (and indeed not even possible almost by definition) (Holland, 2011: 169). While this is a useful counterpoint to traditional Marxism, I believe Holland downplays the “ecologically dominant” tendencies of capitalism, and thus the fact that while societies *are* composed of heterogeneous elements they are nonetheless constrained by an ecologically dominant logic.

radical “negation” of capitalism, instead positing only continuous transformations (Zizek, 2012; Noys, 2011). However, from a CT-inspired perspective, the “negation” these theorists discuss should instead be understood as a bifurcation at the world-system scale, which must emerge from (while simultaneously reinforcing) bifurcations at regional, national, and local scales in a complex set of feedback loops (Srnicek & Williams, 2015). As Eugene Holland explains,

> The question then becomes how we might conceive of pushing a critical mass of existing institutions to ‘de-cohere’ from the tendency to reproduce the consistency of the military-industrial-fossil-fuel complex, and perhaps contribute to the creation of some other form of social consistency instead. Under what conditions and as a result of whose actions would such a shift become possible? (Holland, 2016: 569-570).

Mapping and Minor Science

The final key aspect of D&G’s framework, for our purposes, are the related concepts of “mapping” and “minor science”. As D&G explains, mapping does not simply aim to reproduce or “trace” an existing reality but to simultaneously illuminate and contribute to its processes of becoming-other, or its “lines of flight”. In their words, mapping

> is entirely oriented toward an experimentation in contact with the real…It fosters connections between fields…The map is open and connectable in all of its dimensions; it is detachable, reversible, susceptible to constant modification (Deleuze & Guattari, 2004: 14).

Delanda emphasizes that these should be understood as “intensive maps”, which don’t simply trace a given structure of actuality but serve to highlight the tensions, vectors, and differential relations that work to push this reality beyond its present configuration, while also anticipating critical points at which quantitative changes may become qualitative bifurcations (Delanda, 2016: 110). But rather than simply creating intensive maps for the fun of it (or as an intellectual exercise), Deleuzo-Guattarian mapping should be understood as simultaneously a practice of mapping an individual's location in a broader field of flows and strata (encompassing political-economic and non-human forces and structures), understanding the constraints they impose on its individuation capacities, and working to transform these structures in order to enhance these capacities. Here we are simultaneously within and beyond the realm of Marxian Historical Materialism: within in the sense that we are analyzing the conjuncture – the structural forces and tendencies that constitute the present – as a problematic in which praxis must locate itself; and beyond in the sense that it looks beyond an analysis of capitalism and the balance of class forces to account for the state of the earth system, technological evolution, psycho-social desire, and other parameters.

While Deleuze and Guattari distinguish this more philosophical conception of mapping from "science", this perspective by no means denies the value and reality specific to science, and Deleuze and Guattari are unique among continental philosophers for the inspiration they draw from scientific and mathematical discourses, especially evolutionary theory, energetics, information theory, and Riehmannian geometry (Delanda, 2005). Rather their claim is simply that scientific descriptions don't exhaust the real since they narrow their sights on the actual, while philosophy – or what they elsewhere call "minor science" – is needed to illuminate the virtual harbored within the actual. As D&G describe, the minor sciences

> subordinate all their operations to the sensible conditions of intuition and construction – following the flow of matter… Everything is situated in an objective zone of fluctuation that is coextensive with reality itself…All of this movement is what royal science is striving to limit when it reduces as much as possible the range of the 'problem-element' and subordinates it to the 'theorem-element' (Deleuze & Guattari, 2004: 412, 399).

In this sense, a “minor” approach to Historical Materialism (and world politics more generally) is a matter of following the complex flow of global tendencies, events, and feedback mechanisms while being attuned to possible points of bifurcation and unactualized potentials. It is a matter of forming dynamic and reconstructible maps of key processes, relations and tendencies that evolve as problems and events in the world unfold, rather than postulating a fixed set of causal relationships between variables that can be quantitatively defined (as in modeling approaches). In the words of Deleuze and Guattari, these would be maps that are “open and connectable in all of [their] dimensions…detachable, reversible, susceptible to constant modification” (Deleuze & Guattari, 2004: 13). While quantitative modeling can be a useful enterprise for understanding relations between variables and short-term trajectories, the flexibility and openness of a Deleuzo-Guattarian minor scientific mapping is needed to truly grapple with these intersecting intensive processes in all their uncertainty and complexity. But rather than a dismissal of quantitative rigor, this involves an embrace of imagination, intuition, and narrative skill that must be disciplined by (without being reducible to) the best of quantitative modeling, given that the later can only be at best a useful guide and approximation, and at worst a dangerous simplification of the dynamic challenges confronting us.

In this sense, minor scientific mapping can be broadly read as a “methodology” for theoretically analyzing and practically navigating complexity. This way of re-envisioning Marxist praxis has been given a powerful articulation by Nick Srnicek and Alex Williams. In their words:

> whilst we cannot predict the precise result of our actions, we can determine probabilistically likely ranges of outcomes. What must be coupled to such complex systems analysis is a new form of action: improvisatory and capable of executing a design through practice which works with the contingencies it discovers only in the course of its acting (Srnicek & Williams, 2014: 361).

Unlike classical Marxism, which posited deterministic laws and claimed to *know* the course of history, this *navigational* conception of rational agency is one that aims to "cognitively map" society as a complex phase space of cross-cutting trajectories in order to render social complexity intelligible and enhance capacities for strategic action. The "neo-rationalist" philosopher Reza Negarestani usefully expands on this concept of navigation, which involves

> procedures of steering, plotting out routes, suspending navigational preconceptions, rejecting or resolving incompatible commitments, exploring the space of possibilities, and understanding each path as a hypothesis to new paths or lack thereof (Negarestani, 2014: 444).

In this sense, navigation should be understood as a dynamic theory-praxis dialectic that is constantly updating itself in response to an ever-changing complex and multi-dimensional world, one that can be said to follow Gramsci's desire for a theory that "can accelerate the historical process that is going on, rendering practice more homogeneous, more coherent, more efficient in all its elements, and thus…developing its potential to the maximum" (Gramsci, 1971: 365). While Marxism at its best can in many ways be understood as such an enterprise, concepts from CT and Deleuzian philosophy can help us revise its ontological and conceptual foundations in a way that may be more attuned to the singularity and multi-dimensional complexity of the 21st century planetary crisis convergence.

A comparable "methodology" is being developed by planetary scientists like Paul Crutzen, who advocate for a new "Copernican revolution" to more adequately respond to the sustainability challenges of the 21st century. As he and his co-authors describe:

> Trying to discover or write blueprints for such turbulent, rapidly evolving systems will in many cases prove futile. More important is that we recognize the extent of our ignorance, accept the concomitant necessity to treat policies and other management interventions as experiments, and take measures that will increase our prospects for surviving, and learning from, the experiments we are forced to conduct on ourselves (Crutzen et al, 2005: 18).

In this new paradigm, the emphasis shifts from the importance of "knowledge" to the centrality of "learning" (ibid: 17), which echoes Deleuze's reflections in *Difference and Repetition*:

> the [problematic] is not the element of knowledge but that of an *infinite 'learning'*, which is of a different nature to knowledge. For learning evolves entirely in the comprehension of problems as such, in the apprehension and condensation of singularities and in the composition of ideal events and bodies…We must compose our singular points with those of another shape or element, which tears us apart but also propels us into a hitherto unknown and unheard-of world of problems (Deleuze, 2004a: 241; emphasis added).

In this sense, while Deleuze's philosophy does advocate a strong dose of humility in our capacity to "know" the complexity of the world around us, his approach can be read as an infinite engagement with the complexity of the problems it poses, a practice of transforming our individual and collective bodies as we navigate the multi-dimensional problematic that constitutes the intensive parameters of our 21st century existence. The complexity theorists John Anderies and Jon Norberg (at least partially) capture this challenge when they write:

> The fundamental sustainability problem faced by society is the fact that the system in which they are embedded has an extremely large number of variables…These state variables interact to generate the *landscape which society must navigate* (Anderies & Norberg, 2008: 162; italics added).

It is this landscape that constitutes the problematic that concerns us: a virtual structure that determines the possibility space of world political evolution, and which sets the tasks or problems that must be resolved by contemporary societies. We are of course dealing here with systems of inexhaustible complexity composed of many dimensions, systems that frustrate the modeling efforts of even the most well endowed complexity theorists (Van der Leeuw et al, 2011). However, as Protevi and Bonta suggest, this doesn't mean that we can't at least use complexity theory as a "folk ontology" to look for patterns, thresholds, and phase spaces that structure social and ecological systems, while also shedding light on the dynamics of "far-from-equilibrium 'crisis' situations" and their possible trajectories (Protevi & Bonta, 2004: 33). Rather than following the disciplinary temptation to restrict the complexity of such systems by focusing on a more manageable range of parameters (such as inter-state competition in the case of realist IR, or the intersection of capitalist and interstate logics in the case of Marxist IR), we should do our best to engage with this complexity if we hope to adequately understand and navigate the planetary crisis convergence.

Conclusion

To sum up, the work of Simondon, Deleuze, Deleuze and Guattari, and complexity theorists provide the conceptual foundations of an ontology and "methodology" that can enable us to cognitively map the planetary crisis convergence, illuminate the feedbacks between its multiple dimensions, anticipate its possible trajectories (or "solutions"), and inform a counter-hegemonic praxis aiming to actualize more just and sustainable futures. But more work must be done to synthesize these concepts as part of a coherent theoretical framework that can build upon the work of Marxists, systems theorists, ecologists, and others attempting to analyze and respond to the crisis convergence. That will be the work of the next chapter.

Chapter Five: Planetary Assemblage Theory: A Conceptual Overview

Having outlined key concepts from Deleuze, Deleuze and Guattari, and Simondon, this chapter will now provide a more synthetic overview of these concepts, while also introducing a couple new concepts that will be important to the analysis (or "mapping") undertaken in the next chapter. This will form the ontological and conceptual basis for the theoretical approach I call "Planetary Assemblage Theory". As discussed in the introduction, Planetary Assemblage Theory responds to the need for new theoretical frameworks that weave together an analysis of political-economic, ecological, and technological systems while navigating between the twin pitfalls of isolationism/holism and universalism/particularism. The influence of "poststructuralist" theory in the social sciences and humanities in recent decades, while posing important questions and creating much-needed critical spaces, has left a legacy of distrust towards "grand narratives" and "Big Theory", including Marxist narratives of emancipation. While early forms of poststructuralism emphasized the role of language and discourse in constructing subjectivity and its understanding of reality, the recent turn to "new materialism" and "Actor Network Theory" (ANT) has counter-balanced this trend by emphasizing the agency of material objects and processes in constituting our social and political worlds. While the return to materiality is much welcome, these approaches have unfortunately tended to take an overly dismissive stance towards Marxism, along with other contemporary historical bodies of materialist theorizing, which are perceived to be among the outdated signposts of the "old materialism" (Edwards, 2010). This stance not only tends to ignore the diversity of Marxist thought and its evolution over the past few decades, particularly in the realm of Ecological Marxism, but also forgoes the systemic analysis and critique of global capitalism at the moment we need it most.

In contrast to these approaches, I believe it is possible to retain much of the Marxist baby while throwing out the totalizing Hegelian bathwater. Rather than facing a choice between the organicism of (certain forms of) Marxism and the "local interventionism" of ANT, new materialism, and Foucauldian approaches, it is possible to develop a theoretical framework that is systemic and synthetic without being totalizing, ambitious without claiming to be comprehensive, and comfortable with complexity and contingency without thereby eschewing prediction and speculation on possible futures. This would be an approach that conceptualizes the planetary real as a multiplicity that is neither one nor many, an emergent entity that is integrated and constrained by the dynamics of capital but without being reducible to it, and that can be mapped in terms of its intersecting and reciprocally determining socio-ecological, cognitive-affective, and military-security assemblages. Furthermore, it develops a form of "crisis theory" (which I call "synthetic crisis mapping") that does not focus solely on political-economic crises deemed "internal" to the logic of capital, but that maps the complex and geographically uneven causal relations between climate, economic, financial, energy, and food systems in order to anticipate possible crisis trajectories and cascades.

The chapter will proceed as an overview of the key concepts of Planetary Assemblage Theory. It will begin with the notion of the "Planetary Assemblage" and its key sub-assemblages, including socio-ecological, military-security, and cognitive-affective assemblages. Next, I will discuss the concept of the "Planetary Problematic", which can be considered the *intensive* counterpart to the Planetary Assemblage: the field of differential relations that impels the individuation of new assemblages and which is currently funneling the Planetary Assemblage towards a catastrophic bifurcation. In turn, each sub-assemblage of the Planetary Assemblage has its own intensive counterpart, which I call the Socioecological, Molar and Molecular Violence, and Existential Problematics. Finally, I will describe how this approach relates to and differs from both the Club of Rome's "World Problematique" and contemporary forms of Integrated Assessment Modeling by elaborating the "methodology" of "Synthetic Crisis Mapping".

The Planetary Assemblage

Planetary Assemblage Theory (PAT) begins from the premise that the space of world politics should be understood in terms of a multi-scalar panarchy of socio-ecological, military-security, and cognitive-affective assemblages – from individual bodies to cities and suburban and rural communities, nation-states, regions, the capitalist world-economy, and the earth system as a whole. As noted previously, assemblages at lower scales collectively compose emergent assemblages at national, regional, and global scales: the earth system and capitalist world-economy form distinct assemblages at global scales, each with their own interlinked sets of attractors and bifurcations, which should both be understood as *psycho-socio-ecological-technological* assemblages (rather than one being "social" and the other "ecological"). Nation-states in turn can be understood as psychosocial-ecological-technological assemblages at smaller scales that are constrained by (while also co-constituting) the phase space dynamics of the capitalist world-economy and broader earth system, while cities and local communities are similarly constrained by while co-constituting the phase space dynamics of their nation-states, and human individuals constrained by/co-constituting their local contexts in turn (Williams, 2017). The psycho-socio-ecological-technological assemblages at each scale retain at least a degree of relative autonomy (with the more powerful nodes having more autonomy than others), and the directionality of influence tends to asymmetrically favor the agency of the higher-level emergent assemblages, since critical transitions in these assemblages will usually provoke critical transitions in lower-level assemblages though the opposite is not always the case. For example, a critical transition in the global climate system would provoke transitions in socio-ecological assemblages across the planet, though the collapse of a particular forest ecosystem (e.g. in the case of a massive wildfire) would typically not by itself provoke a bifurcation in the global climate (though a critical mass of tropical and boreal forest dieback could). Similarly, a financial crisis and economic collapse in key states – e.g. the US, Europe, or China – would almost certainly generate a global crisis that cascades across the world-system, though sovereign debt crises in peripheral or semi-peripheral countries would be less likely to do the same.

In this way, rather than a symmetrical nature-capital dialectic, as in the work of Ecological Marxists like Jason Moore, we have here a geographically uneven and asymmetric panarchy of psycho-socio-ecological-technological assemblages, from the earth system at the broadest level to the capitalist world-system itself, to nation-states, cities and rural/suburban communities, and individual humans. Following Delanda, each assemblage has an actualized regime of attraction (characterized by a particular set of behavior patterns and capacities) as well as a virtual landscape of unactualized attractors separated by bifurcations. Different approaches can zoom in or out to different degrees, focusing on planetary, regional, national, or local scales, but it must always be understood how these scales are co-constitutive, with "causal powers running in all directions" (Byrne & Callaghan, 2013: 45).

The World-Assemblage and Modes of Collective Individuation

Following World-Systems Theory, as well as Deleuze and Guattari's heterodox version, the capitalist world-system can be understood as a rhizomatic assemblage (or axiomatic) that emerges from while simultaneously integrating and constraining all lower level psycho-socio-ecological-technological assemblages to varying degrees. However, PAT distinguishes between "world-systems/assemblages" on one hand (I will from here on out use the terms system and assemblage interchangeably), and "modes of collective individuation" on the other. Following Wallerstein, PAT understands world-systems as assemblages that integrate disparate modes of collective individuation, which can take more heterogeneous forms that preserve the political autonomy of the modes, or more imperialist forms that tend to dissolve their autonomy (though without fully subsuming their cultural singularities). The *capitalist* world-assemblage is conceived as an assemblage that integrates disparate modes of collective individuation and organizes them to pursue the function of capital accumulation, which forms an emergent structure that exerts top-down causation on all lower-level assemblages. In this sense, while not everything that happens under capitalism is *determined* by capitalism, it can be considered the "ecologically dominant" structure governing global and local fields of individuation (Jessop, 2000), in the sense that it shapes other assemblages more than they are capable of shaping it in turn. William Connolly usefully expresses this emergent though non-totalizing conception of global capitalism:

> to talk about a 'world capitalist system' does not mean that everything everywhere is drawn inexorably into it. The system propels expansionary drives within and across regions, but it also co-exists with zones and practices partially outside its provenance…to translate a world-capitalist system into a world

> totality is to misread what is outside it, to miss those things imperfectly incorporated into it, and to present an apolitical orientation to it (Connolly, 2010: 129).

In this sense, contra Delanda, capitalism need not "[account] for every stitch in the social fabric" for us to recognize its emergent global effects (Delanda, 2016: 41). However, Delanda is right that assemblage theory can help develop more nuanced mappings of (and strategic interventions within) world politics (ibid: 48), though this should not blind us to the reality of emergent structuring effects at the scale of the world-system as a whole.

Following Wallerstein, to understand capital's emergent structuring effects requires analyzing its "built-in mechanisms to return [it] to equilibrium, such that relatively large swings…from the expected patterns tend to result in only relatively small medium-run changes" (Wallerstein, 1998: 12). Wallerstein focuses on the discipline of market competition, or what Marx called the "silent compulsion of economic relations" (quoted in Read, 2003: 28), which pressures all agencies within its geographical field of action to adopt capitalist motives while punishing those that don't (Wallerstein, 2004: 24). In the contemporary context this not only includes pressure on businesses to maximize profit and on individuals to sell their labor-power to survive, but also includes pressure on national governments to reduce spending, lower taxes, and promote a hospitable "investment climate" for transnational corporations; otherwise they risk incurring the wrath of the bond markets (making it more expensive for them to service their debt), triggering capital flight, getting downgraded in the World Bank's "Doing Business" report, and/or losing out on foreign investment (Hickel, 2017: 215-216). In this way, as Jason Hickel writes:

> investors can effectively conduct moment-by-moment referendums on decisions made by voters or governments around the world, bestowing their favor on

> countries that facilitate profit maximization while punishing those that prioritize other concerns (ibid: 214).

These negative feedbacks constrain nation-states, cities, rural/suburban communities, and human individuals to individuate within neoliberal capitalist parameters. But these economic mechanisms work in tandem with cognitive-affective, military-security, and sociotechnical attractors to reproduce neoliberalized modes of collective individuation. For example, cognitive-affective patterns (i.e. forms of subjectivity) among individuated individuals tend to reinforce consumerism, individualist notions of responsibility, and alienated relations to nature; sociotechnical systems make it difficult for individuals to relate and reproduce themselves through more sustainable practices (especially in nation-states like the US where it is often difficult to live and work without a car); and military-security assemblages discipline and police workers, activists, and radical governments aiming to break from the neoliberal consensus (especially in the global south).

While these negative feedback mechanisms indicate the existence of a global-scale attractor that constitutes a capitalist world-assemblage, it is also possible to disaggregate the world-assemblage by mapping the regional, nation-state, urban, and suburban/rural assemblages that it integrates and constrains. We can say that many of these lower-scale assemblages form a distinctive "mode of collective individuation" (what is often colloquially referred to as a "way of life"), which can be understood as a singular composition of geography, material culture, aesthetic practices, preindividual affects, and knowledges (both discursive and embodied) into a collective metastable body that envelopes the rest of the human and non-human universe while forming a singular expression and perspective. A mode of collective individuation is analogous to what Marx called a "mode of production", defined in *The German Ideology* as "a definite form of activity of these individuals, a definite form expressing their life, a definite *mode of life* on their part" (Marx, 1978: 42; italics added). However, the change in terminology expresses the fact that these are metastable integrations of psychosocial, technological, and ecological dimensions that cannot be reduced to an economic "base". Furthermore, following Brand and Wissen's analysis of the "imperial mode of living", it differs from traditional Marxist concepts of the "mode of production" by assigning "greater weight to the micro-level of everyday practice and everyday knowledge" (Brand & Wissen, 2012: 549). Thus while modes of collective individuation are forms of political-economic organization – involving both forces and relations of production – they also form a "world", or an "ontological formation" that tends to create particular kinds of individuated subjects (in the case of capitalism: the individualized (neo-)liberal subject), particular relations to nature, and particular understandings of the universe (Mitchell, 2014; Allan, 2018). These modes can vary on a continuum from more homogenous or "organic" forms (e.g. Indigenous communities that share a common language and history along with common practices of socio-ecological reproduction, ritual, and mythology) to more heterogeneous or "rhizomatic" forms (e.g. multi-cultural societies like the US). In this sense, the "American way of life"[103] could be considered a rhizomatic mode of collective individuation that involves both the global material-energetic flows, infrastructures, and supply chains that sustain American consumption (Cowen, 2014), as well as the cognitive-affective patterns (or "structures of feeling") that subtend American

[103] Of course the "American way of life" is itself internally differentiated, with many regional subcultures and diverse counter-cultural currents that aim to create new ways of life that express alternative values (e.g. ecological sustainability, anti-imperialism, African American radicalism). However, these counter-cultural currents should be seen as *potential* modes of collective individuation that are constrained by the configuration of political-economic and infrastructural power that defines the dominant American way of life. At the same time, the 19th century civil war and ongoing tensions between "White/Christian America" and "Multi-Cultural America" show that the American mode of collective individuation is a tense and contradictory formation that is already destabilizing and may fragment in the coming decades (Turchin, 2016; Neiwert, 2017).

identity, especially its "deeply felt visions" of freedom, individualism, and mobility (Huber, 2013: xi).

Modes of collective individuation throughout history have primarily taken localized and small-scale forms (whether sedentary or nomadic), though they also occasionally expanded and synthesized to form emergent "civilizations"[104] where shared patterns of geography, language, agriculture, religion, and aesthetics (e.g. culinary, architectural, and artistic practices) gave cultural consistency to a region (often imposed through imperialist integration). Yet local patterns of collective individuation retain distinctive qualities and practices even as they are swept up in a higher-order process of collective individuation. In this sense, following Simondon, collective individuation (at all scales) is not an "organic" process that subsumes/homogenizes its components (though this is a tendency actualized to varying degrees in different modes), but rather a process involving an interplay between individual singularities and the emergent transindividual body that integrates them.

In the modern era, the rise of nationalism made the nation-state a locus of collective individuation, integrating (and sometimes destroying) local traditions and languages into a common national "way of life", with new media technologies (the printing press) forming a key component of these emergent nation-state assemblages (Anderson, 1983).[105] In a sense we can see the same thing happening today with

[104] It is worth emphasizing that while it is possible to identify distinctive "civilizations" as historical modes of collective individuation, there is no such thing as a "pure" culture or civilization. Theorists of civilization like Samuel Huntington in this tend to substantialize and thereby essentialize civilizational difference. Instead, as postcolonial theorists and others demonstrate, we must understand these civilizational patterns as hybrid and multiple: the expression of a vast history of contingent encounters (Gruffyd Jones, 2006). This is the sense in which modes of collective individuation "enfold" each other, not forming a substantially separate entity but rather a singularity that positively affirms its difference as well as its imbrication with the rest of the human and non-human cosmos.
[105] As Benedict Anderson writes in his famous work on nationalism: "What, in a positive sense, made the new communities [*we can say, national-scale modes of collective individuation*] imaginable was a half-fortuitous, but

neoliberal globalization, which (often violently) integrates local, national, and regional differences into a common though "abstract" way of life (i.e. the creation of "McWorld"), or what Wallerstein calls a "geoculture" (Wallerstein, 2004: 60; Barber, 1996). Digital information technologies, fossil fueled supply-chains (especially shipping containers), global logistics, and the marketing strategies of transnational corporations facilitate and fuel its propagation. This neoliberalized mode of collective individuation takes distinctive forms in different contexts (e.g. Chinese consumer capitalism has a different style from its American and European counterparts), but all its expressions share commodified and material-energy intensive forms of socioecological reproduction (including the spread of cars, supermarkets, concrete, meat-heavy diets, and single-use plastics); fossil-fueled and digitized sociotechnical infrastructures; popular entertainment practices (i.e. the increasingly global "culture industry"); practices of knowledge production and dissemination (the dominance of neoclassical economics and reductionist science more broadly); and modes of subjectivation based on individualism, consumerism, convenience rather than thrift (i.e. a "throw-away culture"), and alienation from nature. Perhaps most importantly, this mode of collective individuation is tethered to a concept of "progress" and "the good life" that is premised on endless economic growth, consumerism as a way of life, and an ideology of separation from and "conquest" of nature (Lent, 2017; Allan, 2018). Ulrich Brand and Markus Wissen refer to this abstract mode of collective individuation as the "imperial mode of living", which they define as the

> dominant patterns of production, distribution, and consumption that are deeply rooted in the everyday practices of the upper and middle classes of the global

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explosive, interaction between a system of production and productive relations (capitalism), a technology of communications (print), and the fatality of human linguistic diversity" (Anderson, 2006: 42-43).

> North and increasingly in the emerging countries of the global South (Brand & Wissen, 2012: 548).

The expansion of this mode of collective individuation has been a "mundicidal" process in the sense that it often destroys or disfigures other modes of collective individuation (especially indigenous forms) through processes of capitalist expansion, "accumulation by dispossession", militarized intervention, and environmental degradation (Mitchell, 2014; Harvey, 2007). And it has been an "imperial" process in the sense that it has been enabled by "a principally unlimited appropriation of resources, space, labour capacity, and sinks elsewhere—secured politically, legally, and/or by means of violence" (Brand & Wissen, 2012: 550). Overall, while different cities, nation-states, and regions have distinctive styles and ways of manifesting this abstract "way of life", with peripheral regions forming entropic spaces or "sacrifice zones" that primarily support the individuation capacities of core regions (Frank, 2006), they are integrated within and constrained by dominant political-economic, cognitive-affective, and military-security attractors to reproduce themselves according to these same values and practices of socio-ecological reproduction.

As with the capitalist world-assemblage, modes of collective individuation are reproduced via negative feedback mechanisms that tend to maintain the mode within a given attractor, which can be understood (following Gramsci, as well as Neo-Gramscians like Srnicek & Williams) as a hegemonic regime. As Alex Williams explains, an "achieved hegemony consists of a point of *metastable equilibrium* or an *attractor*", whereas counter-hegemonic projects aim "to either navigate *within* the existing phase space regime, or to transform it" (Williams, 2017: 138). As emphasized before, modes of collective individuation are not totalizing structures that subsume all human and non-human components within their patterns and logics of reproduction. Rather, as posited by sociotechnical transitions theory, while a given sociotechnical regime (or mode of collective individuation) is constrained by a hegemonic attractor, there are always exploratory "niches" that "deviate from the [dominant] regime" and which aim "to break down and replace the incumbent regime" (Rotmans & Loorbach, 2009: 185). In other words, niches exist in the interstices of modes of collective individuation where various individuals and communities pursue counter-hegemonic practices based on alternative cognitive-affective patterns, values, and practices of socioecological reproduction. Ecovillages, worker cooperatives, intentional communities, Transition Towns initiatives, solidarity economies, and municipal socialist movements (e.g. in cities like Barcelona; Preston, UK; and Jackson, Mississipi) are clear examples of such niches in the context of American and European modes of collective individuation (Hopkins, 2008; Penha-Lopes et al, 2019). These can be considered what Henri Lefebvre called "heterotopias", or "liminal social spaces of possibility" that harbor the seeds of revolutionary trajectories, though they must reproduce themselves alongside and through spaces of capitalist and state power (and are thus necessarily "impure") (Harvey, 2013: xvii). In this sense, while these niches can be considered "ways of life" in themselves, they are constrained by the dominant socio-ecological, cognitive-affective, and military-security attractors governing their milieus.[106] The work of counter-hegemonic practice must therefore attempt to compose these niches into an autocatalytic movement that can eventually generate

[106] For example, Tom Henfrey, Gil Penha-Lopes and colleagues discuss how community led sustainability initiatives aiming to enact alternative values are constrained by what they call "coercive isomorphism", in which " the demands of incumbent regimes…constrain or otherwise shape their activities" (Penha-Lopes et al, 2019: 70). More specifically, they discuss how these initiatives are constrained by the need to obtain funding in order to survive in a capitalist system, whereas that funding is often contingent on markers of "success" that force them to adopt capitalist values (ibid: 67-69). Many in the Transition Towns movement note the difficulty of displacing consumerist cognitive-affective patterns in the core countries in the global north, which constrains public participation, whereas counter-hegemonic practices in the global south often face state and para-military violence (e.g. the Zapatistas in Mexico, or Indigenous communities throughout the extractivist zones of Brazil, Peru, Ecuador, and elsewhere) (Kuecker, 2017).

progressive bifurcations in the dominant modes of collective individuation at civic, national, and (hopefully) global scales.

It is worth pausing for a moment to consider the utility of creating an (admittedly cumbersome) neologism such as “mode of collective individuation”. Why not just speak of a planetary assemblage composed of global, regional, nation-state, urban, and surburban/rural assemblages at different scales? The main reason, I think, is because it is important to conceptualize both the cultural singularities that designate specific ways of life as well as the processes through which they are integrated and often violently constrained within higher-order assemblages. Violent reassertions of local difference (e.g. Trump, Brexit, and other incipient nationalisms and fundamentalisms across the world-system) show that the subsumption of local modes of collective individuation in an abstract neoliberal mode provokes nativist reaction by undermining local singularities. As I will touch upon later (when I discuss the “Existential Problematic”), these movements are symptomatic of a profound loss of community, culture, and history for many across the planet: a loss of the capacity to truly participate in and feel oneself as part of something larger (i.e. to individuate as part of a process of transindividuation) (Stiegler, 2012). Thus solutions to the planetary crisis convergence must not only involve a world-systemic transition beyond capitalism (necessary though this is), but must also involve the invention, redevelopment, and enrichment of local modes of collective individuation based on their own historical and geographical singularities.[107] In this sense, as many in

[107] Of course this is potentially fraught territory: how can we affirm local singularities while avoiding neo-fascist or exclusionary forms of collective individuation? Exclusionary movements aim to create homogeneous modes of collective individuation based on common ethnicity, race, religion, gender roles, etc; on the other hand, leftist or solidarity-based movements aim to create more rhizomatic modes of collective individuation that synthesize diverse histories, cultures, ethnicities, gender practices, and aesthetics. The challenge for the latter is to move beyond liberal tolerance/aggregation of individual difference towards genuine syntheses that enable “deeper” solutions, in the sense of

the alter-globalization movement recognize, the challenge is to discover a balance between the re-singularization of modes of collective individuation and global solidarity/coordination, which would thus enable the emergence of a new world-assemblage that preserves the heterogeneity of diverse modes of collective individuation at multiple scales – as the Zapatistas say: a "world of many worlds" (Escobar, 2020).

While modes of collective individuation are emergent formations that express a singular way of life, we can analytically distinguish between at least three kinds of assemblages that enter into their composition: cognitive-affective, socio-ecological, and military-security assemblages.[108] It should be emphasized that these are relative distinctions, since the dominant patterns or attractors in each assemblage are co-constituted by the others. But they can be roughly distinguished as solutions to relatively autonomous yet entangled problematics: the problems of socioecological reproduction (what I call the "Socioecological Problematic"), security-from-violence (the "Molecular and Molar Violence Problematic"), and "meaning" or "sense" (the "Existential Problematic"[109]). The resolution of each dimension could be thought of as a metastable attractor linked to the others. For example, the liberal internationalist "solution" to the problem of security-from-violence is entwined with the neoliberal capitalist "solution" to

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creating new forms of community and social relations that help to heal the pathologies associated with the modern individuated individual.

[108] Socio-ecological, military-security, and cognitive-affective assemblages may be considered the counterparts of what Kojin Karatani calls the capital-state-nation nexus. He argues that the state and nation have their own material bases rather being reducible to an "ideological superstructure", and thus any effort to transcend capitalism must simultaneously develop alternatives to the state and nation (Karatani, 2015: xiv). My approach follows Karatani in emphasizing the co-constitution yet relative autonomy of political-economic, military-security, and cognitive-affective assemblages. But Karatani's framework is still a bit too totalizing, which appears to understand the capital-state-nation complex as a closed world-system, which would require a "simultaneous world revolution" in order to transform without falling back into the same attractor (ibid: xix-xx).

[109] In the context of IR this is often referred to as the problem of "ontological security". As Jef Huysmans describes, security not only responds to a fear of violence and death but also a fundamental "fear of uncertainty, of an undetermined condition; a fear of the unknown constituted by the limits of reflexivity" (Huysmans, 1998: 235). Ontological security can then be considered "a strategy of managing the limits of reflexivity – death as the undetermined – by fixing social relations into symbolic and institutional order" (ibid: 242).

the problem of socioecological reproduction, as well as the secular individualist "solution" to the problem of meaning (involving notions of self-worth bound up with wage-labor, monetary gain, and consumerist values like having the latest Iphone). However, collectively they compose a mode of collective individuation with its own set of attractors and bifurcations, and critical transitions in one sub-assemblage will almost always necessitate transitions in the others. Marxists tend to focus on socio-ecological assemblages, which encompass the forces and relations of production that create distinctive patterns of social metabolism and distribution of surplus products and wastes, while treating cognitive-affective and military-assemblages as part of an "ideological superstructure" (Karatani, 2015). But each kind of assemblage forms a solution to a relatively autonomous problematic, and breaking from the present trajectory of particular modes of collective individuation and the capitalist world-assemblage as a whole will require creating new ways of life that compose novel solutions to all three.

Cognitive-Affective Assemblages

First, cognitive-affective assemblages can be understood as compositions of brains, bodies, ideas, affects, and material culture that create particular ways of understanding and perceiving the self, others (both human and non-human), and the cosmos at large. They are solutions to the problem of human existence (the "Existential Problematic"), or the problem of giving sense to life and the place of humans in the broader cosmos, which integrate linguistic, symbolic, affective, aesthetic, and technological components into a metastable formation. Following Protevi, understanding cognitive-affective assemblages requires going both "below and above the subject: below to the myriad physiological and psychological processes whose interaction constitutes the subject, and above to the intermediate level of myriad social groups and networks" (Protevi, 2009: 9). This is the sense in which Simondon understands subjectivity as a *transindividual* phenomena, since it is not simply a property of individuated human individuals but rather emerges through the more-than-individual phenomena of affect, language, knowledge, and material culture (Read, 2015). In this sense, as Simondon and Deleuze argue, we should understand human subjects not in terms of the liberal fiction of autonomous and isolated individuals, but rather as dynamic processes of individuation that integrate brain, body, sociality, and the broader ecological and technological environment (ibid: 17). Following the archaeologist of mind Lambros Malafouris, this means emphasizing "the gray zone of material engagement, i.e., the zone in which brains, bodies, and things conflate, mutually catalyzing and constituting one another", thereby producing particular patterns of meaning, perception, language, and knowledge among human collectives (Malafouris, 2013: 5).

Cognitive-affective patterns, or "worldviews", thus emerge from a complex assemblage of biological, social, technological, and aesthetic components, and like all assemblages they can be analyzed in terms of dominant attractors and a virtual landscape of unactualized attractors and bifurcations. Homer-Dixon and colleagues develop a similar conceptualization when they claim that a "coherent cognitive-affective belief system constitutes a basin of attraction in the state space of possible belief systems" (Homer-Dixon et al, 2013: 351). While there are diverse cognitive-affective assemblages throughout the world today based on singular compositions of history, language, value, and geography, they have been increasingly shaped by a dominant neo-liberal capitalist attractor based on values of individualism, consumerism, and separation from/domination of nature (Lent, 2017: 19). Diverse counter-hegemonic cognitive-affective currents, both progressive and reactionary, populate the global landscape and have been gaining traction as the "organic crisis" of neoliberal hegemony unfolds (Gill, 2010), though their capacities to invent new ways of life remains constrained by dominant cognitive-affective, socio-ecological, and military-security attractors. For example, in the contemporary US, democratic socialist values have been gaining prominence, yet they remain constrained by the dominant cognitive-affective orientation (or "common sense") that frames their policies as "unrealistic" (even as a majority of Americans support them), which is itself reinforced by centrist political narratives, media networks, and a generalized "apathy" among younger populations (itself bound up with the myriad mental health problems plaguing American society) (Heideman & Thier, 2020; Hari, 2018). Yet critical transitions at both individual and collective scales are possible, as Homer-Dixon and colleagues suggest: "Ideological change…is sometimes much more a jump into a new coherent cognitive-affective state than a gradual adjustment of some convictions" (Homer-Dixon et al, 2013: 351). For example, a "critical mass" of individuals, institutions, and media networks promoting counter-hegemonic narratives (often provoked by major events) can reshape individual beliefs and perceptions by making the previously "unrealistic" seem like "common sense" for many,[110] thereby rapidly shifting cognitive-affective attractors on a collective scale (the Covid-19 pandemic may be having this affect today, though it remains to be seen) (Robinson, 2020).

[110] George Monbiot describes the potential for such a tipping point as follows (following the work of Erica Chenoweth): "Humans are ultra-social mammals, constantly if subliminally aware of shifting social currents. Once we perceive that the status quo has changed, we flip suddenly from support for one state of being to support for another. When a committed and vocal 3.5% unites behind the demand for a new system, the social avalanche that follows becomes irresistible" (Monbiot, 2019).

Socio-ecological Assemblages

While cognitive-affective assemblages emerge from a relatively autonomous problematic, and thus are not epiphenomenal to the socio-ecological organization of production, they are of course deeply shaped and constrained by the latter. For example, as Marx recognized, the autonomous, rational, and acquisitive individual of classical political-economy does not represent a timeless human nature but rather a product of liberal capitalist societies (Read, 2015). Stephen Quilley goes further by relating this mode of individuation to the ever-increasing material-energetic basis of capitalist civilization:

> The highly restrained, individuated structure of personality, regulated by an elaborate superego is a product and driver of industrial modernity to just the same degree as the internal combustion engine…capitalism, psychological individuation and liberalism emerged together, remain interwoven and mutually dependent in complex ways, and depend absolutely on a continually expanding throughput of energy (Quilley, 2011: 263).

Cognitive-affective assemblages in this way co-emerge with socio-ecological assemblages and are critical to the reproduction of the latter, though the latter respond to a relatively autonomous problematic – the problem of organizing production to meet a society's material needs – that has sometimes been called "the economic problem" (Keynes, 1932). While they could be called "political-economic assemblages", emphasizing both the forces and relations of production as in Marxist Historical Materialism, I prefer to call them socio-ecological assemblages in order to emphasize the hybridity and interpenetration of political-economic and ecological dimensions. Socio-ecological assemblages in this sense involve interlocking systems of material-energetic extraction, production, and distribution that reciprocally determine each other and their associated ecologies. For example, the concept of the "energy-water-food nexus" describes how systems of food, water, and energy production are mutually dependent: water and energy is needed to grow food, energy is needed to pump and purify water, water is needed as a input in energy production (e.g. for cooling power plants, and as input for production of biofuels), and food can in turn become an energy input (through the production of biofuels or through its waste products) (D'Odorico et al, 2018). From there we might expand our analysis to include other critical components: especially finance, since financial assemblages form the primary conduits of political-economic power that both directly and indirectly shape these assemblages according to logics of privatization and competitive capital accumulation, seen in the widespread privatization of public infrastructures through neoliberal restructuring and "land grabs" divesting peasants around the world from control over food production (Clapp & Isakson, 2018). Information and transportation networks are also of course crucial to the functioning of these political-economic assemblages, creating the technical infrastructure that supports neoliberal globalization (in combination with fossil fuels) and provisioning systems that combine ruthless economic efficiency with absurd ecological-energetic inefficiencies.[111]

Overall, we can map a behemoth global energy-water-food-finance-information-transportation-chemical assemblage[112] as the socio-ecological base for the hegemonic neoliberal-capitalist mode of collective individuation (or "imperial mode of living") (Brand & Wissen, 2012), with its key nodes in the global north and new nodes expanding

[111] Jeff Rubin, for example, explains a typical supply chain in the food system: an Atlantic salmon caught in Norway is taken to a port where its frozen and transferred to another vessel, taken to another port (Hamburg or Rotterdam), where it is transferred to another ship and taken to China. There the whole salmon will be thawed and processes on a factory floor; then refrozen, packaged, stowed on another container ship and sent to a supermarket in Europe or North America. Two months after it was caught the salmon will be thawed, displayed on crushed ice and sold as 'fresh' (Rubin, 2009: 2).
[112] It is always possible to out-do oneself in creating ever-longer hyphenated names for specific assemblages.

throughout the global south. These global socio-ecological assemblages can be understood as an interlocking network of metabolic infrastructures that reciprocally determine each other, and which are primarily configured and controlled by an oligopolistic structure of transnational corporations and investors with networked interests across the food, energy, and financial sectors (Vitali et al, 2011).[113] While these assemblages have emergent global properties, they have a networked (rather than centralized) structure with multiple key nodes. For example, 23% of the world's total cropland accounts for over 70% of its total grain production (i.e. the "breadbaskets" of the world), with the vast majority concentrated in China and the United States followed by India, Brazil, and Russia (Janetos et al, 2017). The United States, Saudi Arabia, and Russia are the world's top oil producing countries; Saudi Arabia, Russia, and Iraq are the top oil exports; and Saudi Arabia, Venezuela, and Canada have the most proven oil reserves. And in the realm of finance, the cities of New York, London, and Hong Kong are the most active centers of financial activity, while the US central bank is the most influential player in the global monetary system due to its ability to determine interest rates for the world's reserve currency and serve as de facto "lender of last resort" in the case of a global liquidity crisis (Tooze, 2018).

While the concept of socio-ecological assemblages emphasizes the reciprocal dependence between critical infrastructure systems (thus demonstrating the error of viewing problems like "food security", "energy security", "water security", "cybersecurity", or "health security" in isolation from each other) (Parker & Schwartz,

[113] Stefania Vitali and colleagues in their study of the oligopolistic structure of the global economy conclude: "nearly 4/10 of the control over the economic value of TNCs in the world is held, via a complicated web of ownership relations, by a group of 147 TNCs in the core, which has almost full control over itself. The top holders within the core can thus be thought of as an economic ''super-entity'' in the global network of corporations" (Vitali et al, 2011: 4).

2010), the concept of a mode of collective individuation emphasizes that these systems are bound up with a way of life and not simply about supporting "life-in-general", or meeting basic needs abstracted from systems of meaning and power. For example, as activists from La Via Campesina emphasize, growing food and eating is not simply about surviving; it is a cultural act infused with meaning and style, which requires "strengthening cultural practices that do not reduce food and agriculture to the price form" (McMichael, 2013: 59). It is something that has been lost in the abstract mode of collective individuation created by capitalism, taken to its extreme by neoliberalism, which promotes a hyper-functionalist way of life that sacrifices traditional modes of collective individuation to the altar of "efficiency" (of course, as noted, an ecologically irrational understanding of "efficiency"). Resolutions of the SEP are thus inherently entangled with resolutions of the EP. This is why enforcing alternative socio-ecological solutions onto other communities (ostensibly intended to make them "wealthier") often disfigures their cultural singularity and destabilizes their existential or "ontological security", which can contribute to escalating ethnic tensions and the emergence of religious fundamentalisms.[114] In an age marked not only by ecological and economic crisis, but also an increasingly global and acute "ontological security crisis" – the symptoms of which can be seen in new forms of religious extremism, neo-fascist revival across the global north, and an unprecedented global epidemic of depression and other mental health problems – it is critical that we emphasize the linkages between meaning,

[114] For example, Helen Norberg-Hodge describes how Buddhists and Muslims lived relatively peacefully for centuries together in the Ladakh region of India. But over a period of 15 years during the 1970s and 80s, after the Indian government decided to integrate the region in the global economy, thereby undermining local political-economic systems and communal ties through the spread of American consumer culture, ethnic tensions escalated rapidly, leading to bombings in 1989. This example, one repeated throughout the globe, shows how neoliberal globalization not only undermines local socioecological resilience by making communities reliant on cheap imports, but also undermines their *ontological* security, or their sense of cultural self-worth, by making them feel inferior in comparison to a glamorized rich Western lifestyle, which then in turn can undermine security-from-violence by enflaming ethnic tensions (Norberg-Hodge, 2015).

subjectivity, and socioecological reproduction, which the concept of modes of collective individuation helps to foreground.

Military-Security Assemblages

Finally, we must consider "military-security assemblages" ("security assemblages" as shorthand) to be critical components of the Planetary Assemblage. Security assemblages involve apparatuses of surveillance, policing, military power, and institutional-legal regulations that have the primary function of securing and defending particular modes of collective individuation. In the contemporary context, security assemblages can be seen at all scales, from urban and rural/suburban policing assemblages to national and global security apparatuses. These assemblages could also be called "modes of protection" (Deudney, 2000), with the dominant global mode forming something like a "liberal mode of protection"[115] that emphasizes cooperation and mutual restraint rather than violent confrontation between states, a relative fusion between domestic and transnational policing of criminal and "terrorist" threats to international and domestic order, and intersectionally uneven (and weakening) protection of individual rights (Deudney, 2007; Bigo, 2006). While they remain statist to a large extent, it is possible to identify an emergent global security assemblage that is more than the sum of its parts, seen in the (political and technological) integration of many national security agencies under the leadership of the US and its NATO allies – what Guisseppe Zappala

[115] It is of course arguable that the mode of protection we live under could be called "liberal", but I use this term to emphasize the continued though intersectionally uneven and weakening existence of rights protection, while a critical transition would involve a shift at which "emergency" measures – or the sovereign exception – undermine the last semblance of rights protection even for relatively privileged populations.

calls the "fourteen eyes"[116] (Zappala, 2015). In his words, this forms "a complex network of autonomous intelligence agencies and a series of overlapping agreements and exchange practices that is possible to conceptualize as a surveillant assemblage" (ibid: 253). Didier Bigo similarly argues that the post-9/11 field of security has witnessed a "the interlocking of internal security agencies and the subordination of both military and police to 'intelligence' services", which is characterized by practices of exceptionalism, acts of profiling and containing foreigners, and a "search for a total information awareness" (Bigo, 2006: 386). He emphasizes that this assemblage "does not produce a unified strategy" but is rather an emergent effect produced by the struggles between diverse "security professionals" to evaluate, prioritize, and address different security threats (Bigo, 2005: 6-7). In this sense, while this global security assemblage is by no means a kind of centralized agency (though it may eventually become something like one, as I'll discuss in the next chapter), it nonetheless performs the function of securing the globally hegemonic neoliberal mode of collective individuation from various threats to its "way of life". Of course it is not quite "global", more specific to the US and its NATO allies (with China forming its own transnational security assemblage[117]), but it constitutes the dominant security assemblage that serves to protect and expand the

[116] As Zappala explains, this global security assemblage "is constituted of the Government Communications Headquarters of the United Kingdom (GCHQ), the National Security Agency of the United States (NSA), the Communications Security Establishment of Canada (CSE), the Australian Signals Directorate of Australia (ASD) and the Government Communications Security Bureau of New Zealand (GCSB). Due to the geographical position of its members, its surveillance reach is potentially global. Each partner collects information over a specific area of the globe – in accordance with its national intelligence priorities – and then shares raw data and reports with the rest of the alliance…the community "is more of a cooperative, complex network of linked autonomous intelligence agencies". Yet "their collection and analysis activities are orchestrated to the point that *they essentially act as one*" (Zappala, 2015: 251-252; emphasis added).

[117] See Mozur et al, 2019; Gaffney & Mutsvairo, 2020.

neoliberal capitalist mode of collective individuation (while also possessing relatively autonomous tendencies of its own).[118]

Again, it is important to emphasize how security assemblages are reciprocally constituted by socio-ecological and cognitive-affective assemblages, thereby composing emergent modes of collective individuation. Security and socio-ecological assemblages are conditioned by the same set of infrastructures and technoscientific capacities, and the class relations through which the latter are reproduced critically shape the form and function of security assemblages (i.e. who/what they seek to protect and how). And as critical security theorists like Michael Dillon emphasize, modes of securitization are inextricable from modes of subjectivation; how we think about ourselves and the world shapes how we perceive, prioritize, and respond to particular "threats" (Dillon, 1996). In this sense, security assemblages feedback on and critically shape cognitive-affective assemblages by constructing particular kinds of citizen-subjects that understand themselves, their relation to governmental authority, and their relations to Others in particular ways. This is clearly seen when we consider that non-state terrorism, while it commands a huge proportion of the US homeland security budget, is a comparatively trivial threat to populations in the US and Europe, where there are orders of magnitude of more deaths from "mundane" phenomena like car accidents, HIV/AIDS, heart disease, firearm-related incidents, socio-natural disasters, and pollution (which contributes to more deaths globally than war, disaster, and hunger combined) (Abbott et al, 2007: 40; Landrigan et al, 2017). In this sense, whereas threats like car accidents, pollution, gun violence, and heart disease are simply seen as "normal" to our "way of life", non-state

[118] As Bigo explains, security agencies and professionals are not simply beholden to their governments but possess their own interests in self-preservation and enhancing their autonomy to define and police certain threats (Bigo, 2006: 395-596).

terrorist threats (particularly from Muslims) are perceived as existential threats to North American and European ways of life that requires a war-like response. Thus security assemblages are by no means simply functional structures with the aim of protecting human life; rather they aim to protect very specific *ways of life* with their corresponding values, modes of subjectivity, and practices of socioecological reproduction. This demonstrates that creating new practices for regulating violence, both between and within nation-states, will simultaneously require inventing new cognitive-affective patterns bound up with the emergence of new socio-ecological assemblages, thereby creating new understandings of who "we" are, what threatens us, and how we should collectively respond.

The Planetary Problematic

While the concept of the Planetary Assemblage allows us to map the multiple scales of world politics and their socio-ecological, cognitive-affective, and military-security dimensions, it provides more of a "tracing" of world politics than an "intensive mapping". In other words, it provides a *map of the actual*: of the (relatively) stabilized multi-scalar assemblages that constitute the present conjuncture. In contrast, the concept of the "Planetary Problematic" emphasizes the *intensive ground* (i.e. the problems) from which modes of collective individuation and world-assemblages emerge as "solutions". In this sense, a description of the Planetary Assemblage can be considered an "extensive tracing" of actualized solutions, whereas the Planetary Problematic requires an "intensive mapping" that illuminates the tensions, relations and feedbacks working to destabilize actualized solutions and propel the individuation of novel solutions. Rather than a set of problems that could be "solved" in the typical managerialist sense by already existing modes of collective individuation, the problematic instead impels the individuation of new modes, which will contain their own unresolved tensions and potentials that will propel them to change in turn.

I have made reference to an emergent Planetary Problematic that is more than the sum of its parts throughout the dissertation so far, but we are now in better position to clarify what this means. From a Deleuzian perspective, we can say that the Planetary Problematic is the "matrix of individuation" that sets the conditions, constraints, and tensions that impel the individuation of individuals at all scales across the planet (Delanda, 2016: 158). It is an intersecting field of problems (e.g. producing and distributing food and energy, maintaining individual and collective health, regulating violence, creating meaning and orientation in the cosmos) from which modes of collective individuation emerge as provisional metastable resolutions, and to which they must continuously respond as parameters shift and events in the world unfold. A problematic is in this sense composed by the differential relations between the key processes that modes of collective individuation and world-assemblages "integrate" and which continuously place their existence in question, which includes relations between geography, resource endowments, climate, microbes, science and technological capacities, relations of violence-interdependence, relations of "Otherness", and relations to the universe at large.

We can "metaphorically"[119] imagine the Planetary Problematic as a set of differential equations modeling the relations and feedbacks between these intensive

[119] Of course, for Deleuze, it is no metaphor: there is a real differential calculus in the world from which individuating assemblages emerge as "solutions". But if one prefers to read it as a metaphor then that's fine as well.

parameters, which together would compose an N-dimensional phase space defined by the dependency relations between them. This phase space would model the virtual landscape of 21st century world politics, which includes all the possible attractors, bifurcations, and trajectories down which our entangled psycho-socio-ecological-technological assemblages at different scales may evolve and the novel forms them may assume. Of course such an N-dimensional space could never be quantitatively modeled, nor could all its possible trajectories be articulated through qualitative analysis and description. But the concept of a planetary problematic as an N-dimensional phase space constitutes an *abstract limit concept*, which can guide our concrete analysis of its intersecting parameters and speculations about possible thresholds and future trajectories.

The problematic of human societal evolution has evolved over time from a series of relatively localized or regional problematics into an emergent Planetary Problematic, which Deudney describes as the progression from a pre-modern "archipelago" of weakly or non-interacting political-economic entities to our contemporary "planetary earth", characterized by dense global trade, networked global infrastructures, and the nearly absolute speed and scope of violence-interdependence (Deudney, 2020). The emergence of a Planetary Problematic thus signifies that the individuation capacities of all "human" (and non-human) agencies on the planet are now complexly entangled through relations of socioecological, technological, informational and violence interdependence. However, this doesn't subsume all local and regional problematics into a "totality" but rather constitutes a transversal field of intersecting problematics that is not reducible to the sum of its parts. Edgar Morin's articulation of "planetary thinking" effectively expresses this condition:

> There is no single vital problem, but many vital problems, and it is this complex intersolidarity of problems, antagonisms, crises, uncontrolled processes, and the general crisis of the planet that constitutes the number one vital problem (Morin, 1999: 74).

In the contemporary conjuncture, this "general crisis of the planet" includes interlinked crises in the socio-ecological, security, and cognitive-affective assemblages that constitute contemporary modes of collective individuation and the world-assemblage as a whole, though the precise contours of the crises and nature of possible solutions emerge from specific individuating perspectives within the planetary problematic. Following Morin, then, in a statement that follows Deleuze, we need a form of planetary thinking that "ceases opposing the universal and the concrete, the general and the singular" (ibid: 131). In other words, we require a framework that weaves together universality and singularity in order to recognize the ontological reality of shared problems without totalizing the problem/solution-space and ignoring diverse individuating perspectives.

While it forms an emergent problematic that is irreducible to the sum of its parts, we can analytically distinguish between three key dimensions of the planetary problematic, which are solved through the creation of socio-ecological, military-security, and cognitive-affective assemblages respectively: the Socioecological Problematic, the Molecular and Molar violence Problematic, and the Existential (or cosmological) Problematic. Again, as noted previously, each forms a relatively autonomous problematic, though solutions to each are entangled with the others such that they collectively compose modes of collective individuation.

The Socioecological Problematic

The Socioecological Problematic (SEP) refers to the problem of producing and reproducing the material-energetic and technological conditions of human life alongside its preindividual geological-biological-ecological-climactic milieu. Following Marxist Historical Materialism, it is not simply a matter of techniques and practices (the forces of production) but also a matter of the social relations and modes of power through which collective labor is organized, socioecological wealth and wastes are distributed, and surpluses are produced and invested or consumed. The SEP is arguably the central and most ancient problematic in the history of human evolution, encompassing the reproduction of human endo-somatic metabolisms and over time the *exo*-somatic metabolisms[120] of increasingly technologically-mediated and sedentary modes of existence (Kraussmann et al, 2016: 64). It is a problematic that many champions of Western capitalism believed to be "resolved" once and for all by the abundance of industrial productivity, a recurrent challenge that modernity had banished to the dustbin of history through its purported discovery of the secret of immortal life (i.e. infinite growth), but which is today fundamentally called into question by an inescapable horizon of converging crises. Solutions to the SEP take the form of socio-ecological assemblages, which can be thought of as dissipative structures that "integrate" the differential relations between climate, soil, microbes, plants, insects, energy sources, and other eco-geographical features of their local milieu to produce a continuous flow of endo and exo somatic necessities that reproduce a given way of life. Such solutions are always metastable or provisional, subject to destabilization and transformation (or "collapse") in response to unresolved tensions and changes in key parameters (Tainter, 1988; Catton,

[120] Endosomatic metabolism refers to bodily reproduction, while exosomatic metabolism refers to the reproduction of technical infrastructures – the "exoskeleton" of modes of transindividuality.

1982). The repetition with a difference of these dynamics of destabilization and collapse throughout history shows that the SEP is never fully “solved”. There have only been provisional resolutions that eventually collapsed under the weight of their own unresolved tensions, and current trends suggest we are again living through the end of a particular historical resolution. As this world sinks into crisis, the virtual reveals itself with renewed force, thereby demanding a renewed exploration of the possibility space of socioecological reproduction beyond the fetters of the present mode.

Just as Deudney maps a progression from archipelago, to global, to planetary earth in the scope of violence-interdependence (Deudney, 2007), we can see a similar progression in the scope of socioecological-interdependence throughout history. SEPs have been relatively localized throughout most of human history – how to produce and sustain a livelihood in this geo-ecological-climatic milieu? – with the key dimensions of socioecological reproduction produced and distributed locally, while the vast majority of long distance trade involved luxury goods (Chase-Dunn & Hall, 1997). Various forms of imperial expansion have integrated these local problematics to varying degrees, notably the “hydraulic regimes” that formed the basis of many past empires (Wittfogel, 1963), though the capitalist world-assemblage (especially in its globalized neoliberal form) has created an emergent planetary-scale SEP that is unprecedented in both its integration of local problematics and its transformation of the earth system, and which makes local and regional solutions less dependent on their specific eco-geographical milieus (Wallerstein, 2004; Moore, 2015). This does not vitiate the specificity and relative autonomy of local and regional SEPs, whose specific configurations of geo-ecological-climactic relations still condition the viability of local livelihood-making strategies (and which will become increasingly important if the material-energetic foundations of globalization erode), though it does require an analysis of the emergent planetary-scale parameters that shape and constrain the viability of all livelihoods across the globe.

The Molecular and Molar Violence Problematic

Connected to this, though relatively autonomous, is the (inelegantly named) Molecular and Molar Violence Problematic (MMVP) (or "Violence Problematic" for short). While the MMVP can be considered a Deleuzian rearticulation of Deudney's "anarchy-interdependence" and "hierarchy-restraint" problematiques (Deudney, 2007), it is also in some respects a continuation of the classical problematic of security as articulated by Hobbes. As critical security scholars have long recognized, security-from-violence is fundamentally concerned with the *resolution* of the "problem of political order itself" (Krause & Williams, 1997: x), for which the modern state and its military-security assemblages are merely one possible and historically contingent solution. We might also call this the "Hobbesian problematic", which conceives the problem of security as one of constraining political violence, whether within a polity or between polities, thereby exiting the "state of nature". However, following Deudney, the MMVP refers not just to the problem of "exiting anarchy" (i.e. constraining violence both within and between states) but also to the problem of "constraining hierarchy" through checks on the securitization capacities of states (Deudney, 2007). Thus as with Deudney's Republican Security Theory, the goal is to create security assemblages that regulate and constrain various forms of violence-from-below (molecular violence) without thereby empowering and intensifying state (molar) violence.

In the framework developed here, molecular violence refers to flows of "micro" violence (relative to the gaze of the State) that disrupt and harm the functioning of individual bodies and their modes of collective individuation. Thus it can include violent crime, non-state terrorism, rape, disease vectors, industrial accidents, sabotage, and "natural" disasters among other things, though states of course tend to prioritize certain threats more than others. While molecular violence can be classified as "human" or "non-human" depending on its "efficient cause" (which can be difficult to disentangle), it (almost) always involves an assemblage between the two, seen for example in gun violence, the disruption of critical infrastructures, pandemics, bioterrorist attacks, cyber-attacks, extreme weather events driven by anthropogenic climate change, "natural" hazards made lethal by fragile infrastructures, and the "slow violence" of toxic pollution (N. Smith, 2006; Nixon, 2011)). Molar violence, on the other hand, refers to the violence of the state, both military and police, which is wielded both externally (against other states, populations and militaries) as well as internally (against persecuted minorities, law-breakers, political activists, etc.).[121]

While the problem of constraining molar and molecular violence is thus a relatively autonomous problematic, we must emphasize how it is entangled with the SEP. In particular, we can say that molar and molecular violence (almost always) express the *structural* violence inherent in particular solutions to the SEP. Structural violence is defined by Johan Galtung as the indirect violence of material deprivation reproduced through social structures, which reduces human "somatic and mental realizations…below

[121] There is also a complex middle ground between molecular and molar violence, referring to more organized and self-sustaining flows of molecular violence that don't reach the level of a state (such as organized crime, gangs, terrorist networks, militias). The molecular/molar relation is therefore largely a relative distinction, but it is primarily intended to distinguish more ephemeral flows from those that expand and consolidate into more institutionalized forms.

their potential realizations" (Galtung, 1969: 168). It highlights the "abstract" (though no less real) structures that destroy certain bodies in less spectacular ways, which concerns the self-sustaining composition and distribution of flows of wealth and power that support the individuating capacities of certain modes of collective individuation and bodies (usually white, male, heterosexual, and North American/European) at the expense of others. Mitigating and gradually abolishing relations of structural violence can be considered the primary goal of counter-hegemonic movements of economic-ecological justice, whereas governments and security agencies are typically concerned with managing the *symptoms* of structural violence, or at best attenuating the latter in order to increase social stability.

It is possible to map dynamic relations between structural, molecular, and molar violence. The more structural violence a mode of collective individuation or world-assemblage contains (i.e. the more intense its levels of exploitation of both humans and non-humans), the more molecular violence it will typically unleash (both human and non-human, which inevitably resist having their powers constrained or destroyed[122]), and thus the more molar violence it will invoke to constrain the flows of molecular violence. In short, in the words of the common protest refrain, "No Justice, No Peace!" While this is a general tendency, it does not necessarily always hold, since an order marked by intense structural violence may be "legitimized" through ideological or other means. However, while phenomena like nationalism, religious cohesion, or capitalist ideologies of individual responsibility can sustain the legitimacy of orders of structural violence for a

[122] Of course this is not always the case, especially regarding non-human molecular violence, which is often indifferent to the degree of human exploitation (especially in the case of an asteroid, volcano, or earthquake). However, in the age of the Anthropocene even earthquakes and volcanoes have become bound up with processes of human exploitation, since melting glaciers may increase their frequency and intensity (McGuire, 2013). The correlation between structural ecological violence and non-human molecular violence is also seen in increasingly extreme weather, rising antibiotic resistance, and attacks on humans by starving animals.

time, their resilience diminishes as the intensity of structural violence increases. In this sense, a counter-hegemonic approach would emphasize what Antonio Vazquez-Arroyo describes as a dialectic between structural (or "routinized") and eruptive/spectacular violence. The latter is often perceived as "senseless violence", though such perceptions tend to ignore the structural violence acting as "powder keg" for the event (Vazquez-Arroyo, 2012: 218). In complexity theory terms, such events may subject a given mode of collective individuation or world-assemblage to either a non-catastrophic or catastrophic bifurcation: one that continuously shifts its parameters and state variables towards a new point of metastability, or one that ruptures their relations and unleashes a novel set of feedbacks that reorganizes the order towards a new set of structures, relations and feedbacks.

A catastrophic bifurcation in this sense may lead to heightened molar violence and the restriction of collective individuation capacities (i.e. through intensified securitization), diminished structural and molar violence as a result of "progressive" flows of molecular violence (e.g. widespread infrastructural disruptions caused by climate and other activists) resonating in a counter-hegemonic movement, or collapse and fragmentation as a result of intensified *reactionary* flows of molecular violence that can't be contained by the molar violence of states.[123] It is possible that reactionary flows of human-originating molecular violence could also lead to a surge in progressive flows (e.g. social movements responding to rightwing violence through mass civil disobedience), but it can also feedback on itself (seen for example in the vicious feedback loop between Islamic terrorism and rightwing violence in the US and Europe). It is thus

[123] Whereas progressive flows of molecular violence can be considered "negentropic" tendencies towards bifurcation from the hegemonic order of structural violence and creation of more egalitarian forms of collective order, reactionary flows refer to *entropic accumulations* that merely amplify systemic chaos (Molina & Toledo, 2014: 285).

necessary to think carefully about how these flows might actualize and evolve in the context of converging global crises with attention to both their potentially progressive as well as destructive consequences.

The Existential Problematic

The third key dimension of the Planetary Problematic could be called the Existential or Cosmological Problematic, which refers to the problem of creating meaning and values for communities to orient themselves in a strange and often chaotic universe. As Clifford Geertz recognized, the human is a "meaning-seeking animal", with religion, art, and ideology constituting "attempts to provide orientation for an organism which cannot live in a world it is unable to understand" (quoted in Lent, 2017: 31-32). Simondon also recognizes this problematic as a unique attribute of human individuation, which he describes as an "unliveable" excess of preindividual being within the individuated individual impelling it to seek higher forms of resolution in community, religion, art, etc. (Combes, 2013: 32). For Simondon, this unliveable excess within human subjectivity means that "the human being still remains in evolutionary terms unfinished, incomplete" (quoted in Combes, 2013: 49). Theorists from Nietzsche and Heidegger to Sartre and Jung, and numerous others, identify a similar dynamic of individuation at the heart of human being, one constantly pushing the human beyond itself in seeking an ever more integrative relation to its preindividual milieu. In CT terms, each resolution (which crystallizes in the form of cognitive-affective assemblages) forms an attractor, and we may posit a virtual landscape of attractors and bifurcations between them that represents the possibility space of psychosocial being.

While it is most common today (at least in the social sciences) to speak of ecological, economic, and geopolitical crises, there is also recognition of what has been referred to as a "crisis of meaning", a "spiritual crisis", or a "crisis of modern subjectivity". We can call this a *crisis of the modern individuated individual*, which can be witnessed in global epidemics of depression and anxiety, rising rates of suicide in many countries (including the US), reports of unbearable loneliness for increasing swathes of people in neo-liberalized cultures, and the increasing virulence of nationalism and religious fundamentalism across the world-system.[124] The philosopher Bernard Stiegler, who was highly influenced by Simondon, understands these phenomena as symptomatic of what he calls a "generalized loss of individuation" (Stiegler, 2012: 10). He believes that the gradual subsumption of our life-worlds by marketization means that the majority of individuals can no longer participate in a genuine "we" that simultaneously engenders the production of individual singularities (ibid: 60). He contends that this subsumption "renders the process of projection by which a we constitutes itself", or by which a set of individuals can feel themselves as part of a collective, "practically impossible", which then "manifests itself in somatizations, neuroses and obsessional behaviors of compensation or avoidance", including destructive and suicidal behavior (ibid). Jodi Dean similarly perceives these trends as signaling a crisis of the individuated neoliberal individual: "depression, anxiety, autism, and hyperactivity signal the breakdown of a form that was always itself a problem, a

[124] The World Health Organization drafted a report in 2012 calling depression *the* major health hazard of this century (Marcus et al, 2012). A survey conducted in 17 countries found that 1 in 20 people reported having an episode of depression in the past year. It was estimated to affect 350 million people worldwide and is predicted to become the 2nd leading cause of world disability by 2020, and the largest by 2030 (ibid). Recent studies also show that ongoing epidemics of loneliness, social isolation, anxiety, and drug abuse pose an equal danger to public health, which may be responsible for rising suicide rates in the US (up 30% between 2000 and 2016) and elsewhere (Brueck, 2018). In the words of a recent report from the Lancet, these trends signify "a collective failure to respond to this global health crisis", thereby resulting "in monumental loss of human capabilities and avoidable suffering" (quoted in Boseley, 2018).

mobilization of reflexivity, a turning inward, to break connection and weaken collective strength" (Dean, 2013: 73). Fritjof Capra emphasizes the role of Cartesian dualism, which posits ontological separations between mind/body and humanity/nature, in propagating these forms of mental dis-ease across the globe:

> For people whose existence is dominated by this mode of experience no level of wealth, power, or fame will bring genuine satisfaction, and thus they become infused with a sense of meaninglessness, futility, and even absurdity that no amount of external success can dispel (quoted in Lent, 2017: 377).

While the dualistic consciousness of Cartesian subjectivity was intensified and propagated by the rise of capitalism, it cannot be reduced to the latter. Instead, as Jeremy Lent shows, echoing earlier arguments made by Heidegger, this cognitive pattern was "created by the [Ancient] Greeks, systematized by Christianity, and endorsed by reductionist science" before becoming both cause and effect of the rise of capitalist modernity (Lent, 2017: 401).

Therefore, the project of inventing new solutions to the EP is not only a struggle against capitalism but also a more ancient pattern that came to dominate the European mind before spreading to the rest of the world. Nonetheless, enabling a widespread bifurcation from this cognitive-affective pattern will require new solutions to the SEP beyond capitalism, while the latter will in turn require new solutions to the EP. Which would come first? Which would be primary? It should be clear that these are the wrong questions. Instead, progressive niche experimentation in cognitive-affective and socio-ecological assemblages will need to mutually catalyze and amplify each to enable local, national, regional, and world-systemic scale structural reforms (e.g. a "Green New Deal") that could further enhance the individuation capacities of novel modes of collective individuation based on alternative solutions to the EP.[125]

Posing and Resolving the Problematic: The Role of (Counter-)Hegemonic Agency

We have not yet discussed how socio-ecological, military-security, and cognitive-affective assemblages emerge from their respective problematics. The language of the problematic evokes the legacy of structural-functionalist theories, which view social formations and practices as adaptive responses to specific problems. A Deleuzian-Simondonian approach to the problematic is not entirely opposed to this view, as we saw in the previous chapter (i.e. the eye as solution to a "light problem") (Deleuze, 2004a: 263), but it is not the same either. A problematic *impels* resolution in the form of individuating assemblages, in the same way that tensions impel the search for equilibrium (or metastability, as in the case of far-from-equilibrium systems), and constrains the possible forms that these assemblages can assume (Delanda, 2016). But an assemblage does not simply emerge deterministically as a reactive response to problems; instead, creative agency is needed, multiple possible solutions are always possible, and (at least in the social realm) which solution is "chosen" is always a matter of power and (counter)-hegemonic struggle.

In the case of the world-assemblage, world-systems theorists have shown how hegemonic agencies –involving coalitions of leading states and fractions of capital – are able to successfully *pose and resolve* the problems of a particular era, creating new ways of understanding problems and then imposing "solutions" through a mix of coercion and

[125] See Deudney and Mendenhall on the creation of earth-based identities as a central component of this problematic (Deudney and Mendenhall, 2016).

consent (Wallerstein, 1974b; Arrighi, 2010). In fact, the emergence of the capitalist world-assemblage can be explained as the result of the dominance of a new way of posing and responding to the SEP, involving the rise of what Jason Moore calls the "law of value as a law of Cheap Nature" (Moore, 2015). In this way, the emergence of capitalism involved the rise of new modes of collective individuation based on separation from, calculation of, and control over "Nature", which was pioneered and expanded by emerging Western European state-capital nexuses during the long 16th century. For example, discussing how capitalist practices emerged from the crisis of feudalism – itself a complex concatenation of socio-ecological problems involving climate change, soil degradation, disease, population growth, overconsumption by the feudal classes and insufficient investment in productive innovation (Moore, 2015) – Wallerstein writes:

> if the optimal degree of productivity had been passed in a system *and* the economic squeeze was leading to a generalized seignior-peasant class war, as well as ruinous fights within the seigniorial classes, then the only solution that would extract Western Europe from decimation and stagnation would be one that would expand the economic pie to be shared… The territorial expansion of Europe hence was theoretically a key perquisite to a solution for the 'crisis of feudalism' (Wallerstein, 1974: 24, 38).

In this sense, we can see how the creation of a capitalist world-system – involving the rise of capitalist agriculture in Europe, the conquest and socio-ecological transformation of the Americas, the rise of the slave trade, and the emergence of the modern plantation-system (Moore, 2015: 182-183) – emerged a response to a structural socio-ecological problematic – how to appropriate sufficient land, food, fuel, and bullion to enhance the collective individuation capacities of the emergent capitalist-state nexuses in Western Europe (Wallerstein, 1974: 51)? However, Wallerstein emphasizes that there was no centralized agency or coordination involved: "'Europe' must not be reified. There was no central agency which acted in terms of these long-range objectives. The real decisions were taken by groups of men acting in terms of their immediate interests" (ibid: 51). In this sense, the capitalist world-assemblage and its global spanning relations of socio-ecological reproduction emerged as a decentralized response of Western European states and economic elites to the same structural pressures towards geographical expansion and labor productivity enhancement; yet the colonial capitalist solution to come was not pre-ordained but the product of creative and violent agency pioneered by the dominant classes.

However, rather than only focusing on the emergent capitalist solution to the SEP, we must also show how it symbiotically co-evolved with the absolutist state "solution" to the MMVP. The emergence of gunpowder in 15th and 16th century Europe, for example, made it far more difficult for feudal lords to defend their fortresses and thereby undermined their viability, making absolutist states with large-armies the more viable mode of protection (Deudney, 2007). Thus the problems of security and socioecological reproduction were entwined but irreducible to each other, with absolutist states translating capitalist wealth into military power and capacity to fortify themselves from rival states, while leading capitalists took advantage of the protection offered by states and their creation of national markets (Tilly, 1985; Karatani, 2015). Overall this generated a slowly emergent world-assemblage involving a complex and partially contradictory combination of territorial and capitalist logics (which cannot be readily called a "totality", as Wallerstein believes) (Arrighi, 2010; Harvey, 2003),[126] and in

[126] As Arrighi writes: "the close historical tie between capitalism and the modern interstate system is just as much one of contradiction as of unity" (Arrighi, 2010: 33). For example, capitalists often resisted the expansion of state power, which could weaken profitability by diverting resources into military enterprise or disrupting networks of production and exchange through war (ibid).

which the logic of capital accumulation would become “ecologically dominant” at the global scale under the hegemony of the British Empire (Arrighi, 2010: 53).

Arrighi similarly focuses on the role of hegemonic powers in simultaneously resolving the Socioecological and Violence Problematics: how to sustain capital accumulation on an expanded scale while constraining the molar violence of inter-state war (along with the molecular violence of class revolt), thereby satisfying the “system-wide demand for order” (Arrighi, 2010: 30). For example, as he says about the Dutch: “the Dutch ruling group developed much greater capabilities than Venetian rulers ever had to pose and solve the problems around which the European power struggle raged”, in particular the problems of managing the territorial relations between emergent absolutist states (via the Westphalian institutionalization of sovereignty), suppressing domestic rebellions, and creating a peaceful environmental for international commerce (ibid: 48). Later, he notes the capacities of the US in the post WWII era “to pose and provide a solution to the problems around which the power struggle among revolutionary, reactionary, and conservative forces had raged since 1917” (ibid: 66). It did this by catalyzing the reconstruction of Europe, leading the creation of new global institutions – from the UN to the Bretton Woods – to forge a more peaceful and economically stable world order, promoting global “decolonization”, and rhetorically supporting the welfare of all peoples through “high mass consumption” above the absolute rights of property (ibid: 67). Jason Moore builds on Arrighi while emphasizing the socio-ecological character of these hegemonic transitions, showing us how they involved organizational and technological revolutions that gave leading states “unprecedented command of the world's human and natural resources" (with peat, coal, and oil playing key roles for the rise of Dutch, British, and American hegemony respectively) (Moore, 2015: 160).

In these passages we can see that hegemonic agencies during a particular age confronted a problematic determined by the relations between class conflict, (inter)-societal competitive pressures (both military and economic), geology, climate, and microbes (among other dimensions), which constrained the range of possible solutions available to would-be hegemonic powers. Yet *how* they responded was a matter of creative agency – an "exploration of a space of possibilities" – that involved discursively articulating the problematic, mapping its contours, and then and developing techniques of power and intervention to forge new political-economic and military-security assemblages aligned with their interests.

But we should also go beyond WST approaches, which give a valuable yet limited historical account of how these problematics have been posed and the various agencies involved. On one hand, WST (and Marxists generally) tend to focus on the capitalist resolution of the SEP rather than understanding how capitalism symbiotically co-evolved with military-security and cognitive-affective assemblages, which is due to the tendency to think of capitalism as a totality. Thus for Wallerstein military competition and the state system are functional appendages to the reproduction of capitalism, though others (e.g. Arrighi and Harvey) acknowledge their relatively autonomous logics (Arrighi, 2010; Harvey, 2003). Going further, we should also explore how these assemblages co-evolved with cognitive-affective assemblages; for example, returning to the long 16th century, we can see how the emergence of new cognitive-affective assemblages were both cause and effect of processes of state-formation and market-driven development (Anderson, 2006).

Emergent national identities, made possible by the printing press, markets for books, and the imposition of national languages, formed a solution to the EP – creating new forms of meaning and belonging – that was entwined with the absolutist state solution to the MMVP and the emergent capitalist solution to the SEP. However, the emergent nationalist solutions to the EP were relatively autonomous, not merely epiphenomenal or functionally reducible to the needs of capitalist expansion and absolutist state-building; they also provided a new source of meaning and grounding for populations in an era of religious upheaval and weakening of earlier forms of community under the state-capital nexus (Karatani, 2015: 209).

Furthermore, Marxists tend to ignore the role of knowledge and new forms of "expertise" in shaping how hegemonic agencies pose and respond to the problems of socioecological reproduction, security, and meaningful existence. Thus Jason Moore, breaking from traditional Marxism, emphasizes that "the production of knowledge itself is constitutive of capitalist world-praxis", particularly the production of "scientific and symbolic regimes necessary to identify, quantify, survey" and make possible the appropriation of cheap natures across the planet (as well as the creation of cognitive-affective assemblages based on separation from/domination of nature) (Moore, 2015: 194, 191). Furthermore, as discussed in chapter two, Foucauldians foreground the role of knowledge and subjectivity in constructing governmentality assemblages across the domains of both economy and security, showing how new "modes of problematization" emerge to reshape how hegemonic agencies pose and respond to the entwined problematics of economic and security governance (Foucault, 1984). For example, the rise of liberal political economy in the 18th century – involving new ideas about the object, art, and telos of government – was central to the emergence of more dynamic liberal capitalist societies, which displaced earlier Mercantilist modes of governmentality (Foucault, 2007). Later on in the 20th century, new ideas about "the economy" and "economic growth" became central to how the US posed and responded to the problems of remaking world order in the post-world war II era, which involved novel solutions to the SEP, MMVP, and EP. Not only did they help catalyze the massive socio-ecological transformation towards energy-intensive consumer societies known as the "great acceleration": economic growth also brought increased social harmony to Western states that had been wracked by class conflict, while generating a new ideology of "consumerism" and "the good life" that provided a novel solution to the EP for Western populations (Allan, 2018). Simultaneously, it bolstered the foundations of US military power and enabled, via the Marshall Plan, the formation of a strong "free world" alliance with Europe to counter the communist threat (Barry, 2020). In this sense, while Marxists typically focus on the structure of capital as the determining agency in the modern world-system, Foucauldians emphasize the diffuse assemblages of power-knowledge in the intersecting domains of economy and security – involving assemblages of discourse, embodied cognition-affect, natural and social scientists, think-tanks, government agencies, and international institutions – as key mechanisms for constraining the collective individuations of capitalist societies and shaping their evolution (Bidet, 2015).[127]

[127] Jacques Bidet helps to show how Foucauldian and Marxist analysis can be brought together in a similar sense. Foucault critiques the "Hegelian Marx" as a "thinker of the totality", instead investigating the multiple "apparatuses" that constitute societies, which for Foucault are "made of heterogeneous elements, are misaligned with respect to one another, are always in movement, and…do not form a system" (Bidet, 2015: 4). However, Foucault tends to downplay the existence of a political-economic and class structure that molds and constrains the possible configurations of these power-knowledge apparatuses (ibid: 208-209). After all, how can we adequately make sense of the rise of disciplinary

Overall, Planetary Assemblage Theory follows WST, Foucault, and Gramscian analysis to show how "solutions" to a problematic arise as hegemonic blocs – involving both coalitions of leading states and capitalists as well as specific forms of knowledge, subjectivity, and expertise – articulate the problematic in a specific way and give rise to corresponding solutions. In this sense, the Planetary Problematic is an *objective structure* that constrains the individuation capacities for all agencies in world politics, whether states, capitalists, transnational social movements, cities and small towns. But *how* the crises will be defined, and which trajectories will be "chosen", will be the outcome of struggle between competing hegemonic coalitions and their different values, subjectivities, and forms of knowledge. As Bob Jessop explains, crises

> disturb prevailing meta-narratives, theoretical frameworks, policy paradigms, and/or everyday life and create space for proliferation (variation) in crisis interpretations…the plausibility of interpretations, strategies, and projects depends on their resonance (and hence their capacity to reinterpret and mobilize) in a semiotic field populated by competing imaginaries and their associated standpoints (Jessop, 2012: 19).

In this sense, articulations of and responses to the planetary crisis convergence will be a struggle between competing hegemonic configurations of meaning, subjectivity, knowledge, desire, and understandings of the universe that will vie to shape the trajectories of local/national modes of collective individuation and the world and planetary assemblages as a whole.

For example, in the contemporary context, we can see the emergence of a transnational far-right/neo-fascist bloc for whom the problem is one of "securing" their identities and energy-intensive ways of life at the expense of racialized and feminized "others". For them the "solution" is thus an end to immigration, the creation of ethnically

societies, liberal governmentality, or biopolitics – all with the aim of making societies more "productive" – without situating them within the rise of a capitalist world-system?

pure states, intensified militarization, and a rejection of science and embrace of conspiracy theory. On the other hand, we see the rise of ecomodernist and "green growth" discourses that remain with the constraints of capitalist solutions to the SEP. For them, the problem is merely one of substituting fossil fuels with renewables, therefore changing our socio-ecological assemblages while retaining the same way of life and relations of power along with the same practices of economic knowledge-power that have brought us headlong into the planetary crisis convergence. Alternatively, we have the ecosocialists, "degrowth" advocates, "commoners", and others who emphasize the impossibility of equitable and sustainable solutions to the SEP so long as we remain in a capitalist growth-based framework. Instead, they advocate new forms of subjectivity based on care, reciprocity, and alternative visions of "the good life", along with alternative forms of knowledge (e.g. Marxism, feminist and ecological economics, earth system science, and indigenous ecologies) that can help us imagine, design, and collectively govern post-capitalist modes of collective individuation.

While agreeing with these post-capitalist approaches to the SEP, I argue that we should also place more emphasis on the need to simultaneously envision new solutions to the EP and link these struggles with those offering progressive problematizations of the MMVP – not just involving progressive solutions to the problems of war and non-state terrorism but also to problems like cybersecurity, biosecurity, nuclear disarmament, and state surveillance (e.g. Rogers, 2008; Abbott et al, 2007; Diebert, 2014; Deudney, 2007; Rigakos, 2016). Following Foucauldians, as well as heterodox Marxists like Kojin Karatani, rather than reducing cognitive-affective and military-security assemblages to the "ideological superstructure" of capital (Karatani, 2015), we need to illuminate the relatively autonomous problematics to which they respond and envision post-capitalist solutions to all three. Instead of thinking that such solutions would necessarily flow from a "negation" of capitalist solutions to the SEP – i.e. that we'll automatically get more progressive solutions to the EP and MMVP once we break from the logic of capital – we need to work on these problematics simultaneously, understanding that it is possible to get post-capitalist solutions to the SEP that would perpetuate the same or similar cognitive-affective and military-security assemblages (i.e. in the case of the ecomodernist left, whose visions of high-tech "ecosocialism" would perpetuate relations of domination toward nature, intensify extractivism in the global south, and exacerbate violence-interdependence). Thus the challenge for a transnational counter-hegemonic movement aiming for social and ecological justice becomes: how can we collectively articulate the Planetary Problematic in a way that simultaneously recognizes diverse-yet-intersecting problems and diverse-yet-intersecting individuating perspectives, and that in doing so can help organize a *consistent* (though non-unified) emergent response?[128]

The Deleuzian Planetary Problematic and the Club of Rome's World Problematique

We may remember that the concept of the problematic hearkens back to the Club of Rome's analysis of a "world problematique" in 1972, understood as a set of interrelated problems where "the whole is more than the sum of its parts", and in which "change in one element means change in the others" (Watts, 1972: 11). Thus there is a clear lineage linking the Club of Rome to PAT's understanding of the Planetary Problematic. However, it is worth emphasizing at least two important differences, which

[128] As Deleuze and Guattari describe, consistency is a matter of "holding together" heterogeneous elements without subsuming their heterogeneity, thereby creating a rhizomatic assemblage rather than an arboreal system the functionally subsumes the parts within the whole (Deleuze & Guattari, 2004: 357, 364).

would differentiate a Deleuzian approach from "technocratic" approaches more generally. First, it is worth emphasizing that the Planetary Problematic is not something that can be "solved" in the sense of discovering the ideal fix for all the problems we face (though it is certainly worth envisioning such ideal solutions). Rather, the problematic, at least in the 21st century context, is more like what some would describe as a "predicament", or a situation to which we can only *respond* to the best of our ability rather than "solve" once and for all (Greer, 2008: 22). Thus when I speak of "solutions" to the problematic, this does not mean a fix to all these problems but rather *a trajectory through them*. This can also distinguish the approach taken here from at least certain versions of Marxism: following Deleuze's stoicism, we do what we can based on our capacities and potentials in situated problematics, which are not simply problems to be solved but conditions and events to be lived out and affirmed to the best of our ability. As Elizabeth Grosz explains:

> The question of ethics [for Deleuze] is how can I be worthy of the events that await me, how can I enter into events that sweep me up, preexist me, or that I cannot control?... It asks: what am I capable of doing, what is my degree of power and how can I act to enhance and maintain an active use of it? (Grosz, 2017: 151, 134).

In this sense, the problematic is a condition to be affirmed and navigated creatively to the best of our collective capacities; it is not an all-or-nothing "revolution or bust" approach which, though we may agree with the necessity, is likely to end in disappointment. However, this doesn't mean we deny the potential for eco-social revolution, and indeed we must fight for this, but simply that we don't put all our eggs in this basket. Instead, counter-hegemonic praxis should be *navigational* in the sense that it modifies its primary goals, strategies, and tactics as the possibility space changes (i.e. as constraints and opportunities emerge and/or dissolve). This must involve a complex negotiation between the ends of transformation and adaptation, understanding and seizing the opportunities for radical change when they arise and knowing when adaptation to ineluctable realities becomes our best option. We should ask: what if an imminent global eco-social revolution is not forthcoming? What then can we do, and how do we live? And how can we take our capacities to the limit and enhance our joyous affects given our situation?

Second, as I briefly alluded to earlier, from a Deleuzian perspective the problematic is not simply a matter of survival that can be solved via technocratic means. Rather, it has an irreducible *ethico-aesthetic* dimension, in the sense that the problematic demands the invention of new ways of life that express alternative values and styles of existence. In this sense, responding to the Planetary Problematic is not merely a matter of creating new practices in the fields of agriculture, energy, transportation, and finance, critical as these are, but also a matter of ethico-aesthetic experimentation to produce new forms of meaning, new understandings of ourselves and the universe, along with new practices of education, leisure, and ritual that express these understandings. In the words of maverick economist David Fleming, it requires an invention of

> culture in its original, earthy senses of the story and celebration, the guardianship and dance that tell you where you are, and who is there with you…It is the context, the story, that identifies a community and gives it existence…It is the common culture and ceremony, the good faith, civility and citizenship, the play, humor and conversation which make a living community (Fleming, 2016: 50, 17).

These ethico-aesthetic concerns must be fundamental to any solution to the planetary problematic, though they will most likely take root in emergent local modes of individuation rather than global scale assemblages. This doesn't mean we dismiss the functional imperatives of survival and the need for natural and social scientific knowledge of psycho-socio-ecological-technological assemblages, as if this were merely a "reactive" concern that distracts from the more "affirmative" task of ethico-aesthetic transformation (as certain Foucauldians imply) (Evans & Reid, 2014). The reactive and affirmative are necessarily entangled, and the problem is one of inventing new ethico-aesthetic practices and ways of life that can live and *live well* on our rapidly changing earth, which will require drawing upon all the natural and social sciences along with the vast storehouse of (largely forgotten and/or repressed) ancestral knowledge and cultural institutions to create new modes of collective individuation.

From Integrated Assessment Modeling to Synthetic Crisis Mapping

While it retains its relevance, the *Limits to Growth* report was an early and now in certain respects dated effort to model the world problematique. Today similar initiatives, encompassing various futurological techniques, are being pursued by inter-governmental organizations, thinktanks, security agencies, and interdisciplinary initiatives throughout the globe. FuturICT, for instance, aims to develop a "science of multi-level complex systems" to "understand the complex interdependencies between the different institutions, infrastructures and networks on which our society is built" (Helbing, 2011), thereby serving as a tool of global governance to navigate the intersecting crises of the 21st century. Planetary scientists and ecologists from the Resilience Alliance similarly aim to develop a global sustainability science, integrating earth system science with diverse local knowledges, to map the possibility space for the coupled evolution of the earth system and global economy while enabling humans "to become active stewards of our own life support system" (Rockström et al, 2011: 11). Most notably, "Integrated

Assessment Models" (IAMs) are being developed to model the feedbacks between different components of the earth system as well as between human and natural systems, which are the basis of the IPCC's "Representative Concentration Pathways" (modeled trajectories of global emissions and temperature increases) and "Shared Socioeconomic Pathways" (trajectories of socioeconomic change in response to climate change) (Calvin & Bond-Lamberty, 2018; Riahi et al, 2017).[129] As the IPCC explains:

> IAMs lie at the basis of the assessment of mitigation pathways…[which] combine insights from various disciplines in a single framework, resulting in a dynamic description of the coupled energy–economy–land-climate system…Such integrated pathways hence allow the exploration of the whole-system transformation, as well as the interactions, synergies, and trade-offs between sectors, and, increasingly, questions beyond climate mitigation (IPCC, 2018: 100).

Some scientists are taking these modeling ambitions even further. The IHOPE initiative (Integrated History of People on Earth), for example, aims to create computational models that integrate dynamics of biophysical systems with human system dynamics (including demography, settlements, agriculture, technology, and institutions) in order "to better understand the past as a means to creating a sustainable and desirable future" (Costanza et al, 2012: 110-111). These scholars aim to synthesize vast reams of historical data to create models capable of simulating possible socio-economic pathways in the 21st century, which they even claim "should be capable of simulating total social collapse"

[129] For example, some IAMs develop highly simplified representations of key earth and economic system components in order to monetize climate impacts (e.g. DICE), while more powerful process-based IAMs develop coupled biogeophysical and economic models to anticipate climate impacts at finer scales (Diaz & Moore, 2017). Verburg et al note that most IAMs distinguish between "environmental" and "social" subsystems and fail to capture important interactions and feedbacks between the two. Further, they note that "due to lack of quantitative understanding of the social system" most models reduce the social sphere to "economic modeling assuming rational decision-making" (Verburg et al, 2016: 331). Diaz and Moore discuss numerous other limitations of existing IAMs attempting to understand future damages from climate change: an *additive* understanding of damages that don't capture synergistic feedbacks; assumptions of smooth and instantaneous adjustments by economic actors, which ignores adjustment costs; inability to represent potential tipping points in earth and human systems; ignorance of how climate impacts will feedback on economic growth; and the (neoclassical) assumption that losses from climate impacts are perfectly substitutable with increased consumption and can thus be fully compensated by higher incomes (Diaz & Moore, 2017: 778-779). Hence the conclusion of economists like William Nordhaus that a 3.5 degree C rise would be "optimal" from a cost-benefit perspective, a conclusion that one might consider to be "anti-scientific" (to put it mildly) (Hickel, 2018).

while also enabling us to help clarify the “safe operating spaces” for the contemporary world system (Verburg et al, 2016: 334).

Planetary Assemblage Theory in many respects matches the ambition (if not the human and computational resources) of such approaches, but with such an immense worldwide effort already underway what could it possibly contribute? At the very least, I would argue that this approach, in conjunction with the work of contemporary Marxists, Foucauldians, and other critical theorists, can enable us to move beyond the often technocratic and apolitical orientation of these global systems approaches, which are beset by a “modeling culture” that ignores how power infuses these systems to reproduce certain forms of life and enhance the individuating capacities of particular bodies at the expense of others (Cote & Nightingale, 2012). While these global systems theorists often identify an abstract “humanity” as the agent that must navigate the emerging crises landscape, more critical approaches are needed to clarify how this global landscape is populated by multiple modes of collective individuation and saturated with counter-hegemonic struggles that are fundamental determinants of the future possibility space. We might go so far as saying that these global systems theorists are not only apolitical, but that they are simply bad systems theorists*,* or at least have a very narrow understanding of the systems they claim to be modeling, since it is impossible to understand the possible individuating trajectories of these systems without understanding the counter-hegemonic struggles, modes of subjectivity, and relations of exploitation that fuel current systemic trends. This is often reflected by discrepancies between their articulations of the problems and proposed solutions, seen primarily in recognitions of the immense sustainability challenges ahead while having a shallow understanding of the political-economic transformations that would be needed to address them, and neglecting the role of political struggle in bringing them about (e.g. Steffen et al, 2018; Rockström & Klum, 2015; Crutzen et al, 2005).

However, to be fair to these approaches, many of them are not only more aware of the inequalities and relations of power fueling the present crisis than their critics give them credit for (Angus, 2016: 227-229), but are also in many ways engaged in a different enterprise (one that is by no means politically neutral, however, as they at times appear to assume). One way to articulate the difference between PAT and these other approaches is via the distinction that Edgar Morin draws between "restricted" and "general" complexity. As he describes, restricted complexity refers to approaches that narrow their conception of a system and its key parameters in order to make it amenable to modeling and quantification. General complexity, on the other hand, involves a more philosophical grappling with the full epistemological, ontological, and existential implications of complexity, emphasizing the irreducibility of uncertainty and the impossibility of adequately quantifying the myriad dimensions that compose a system (Morin, 2006). Nicholas Rescher effectively describes the implications of such a worldview:

> The real has an inner complexity that is humanly inexhaustible and the range of fact inevitably outruns that of articulable truth…Our best available judgments – not only as to the actualities of things but also as regards their plausibilities are probabilities – will always be conditional judgments formed in the context and against the background of the then-available information as best we can determine it. And in this sphere future changes are presently unforeseeable (Rescher, 1998: 35-36, 171).

For these reasons, computational models can only tell us so much about the possible trajectories of the 21st century Planetary Assemblage, let alone for any one of its sub-assemblages. As some scholars of socio-ecological modeling acknowledge, the "problems of parameterizing social dynamics, such as individual behaviour, governance and macro-economic shifts [let alone socio-ecological-technological dynamics], are profound and probably intractable over the near future" (Verburg et al, 2016: 329). Thus we need an alternative approach that, while lacking the computational rigor that some would see as necessary for genuine "science", can more adequately account for the complexity of actually existing psycho-socio-ecological-technological assemblages through a combination of qualitative structural analysis, quantitative trend analysis, historical understanding, and intuition.

In this way, PAT combines quantitative insights from models studying the interactions between the earth, energy, food, and economic systems with a qualitative analysis of political-economic power, technological change, subjectivity, and resistance. In a way it can be read as a Deleuzian or general complexity-based alternative to IAMs, one that is based on mapping qualitative relationships between political-economic, ecological, and technological systems and processes; weaving together historical analysis of world-system patterns with quantitative analysis of biophysical and political-economic trends; substituting technocratic managerialism with an emphasis on counter-hegemonic struggle over the definition of the problems and actualization of solutions; and supplementing computational models with what we could call "synthetic intuition". Whereas computational modeling is an exercise in quantifiable restricted complexity – isolating key quantifiable parameters, determining their relationships through differential equations, and then computing possible trajectories/solutions – "mapping" is a more dynamic and qualitative exercise that involves understanding the key relations and feedbacks between key systems and processes. Rather than determining law-like relationships between parameters and computing possible trajectories (or "solutions"), from a PAT perspectives such trajectories can only emerge through the work of *synthetic intuition* – which must combine historical understanding of previous patterns, quantitative analysis of key trends, and imaginative construction of possible scenarios. It could also be understood as the work of what Sam Mickey calls "imaginative rationality", which is inextricably an act of speculation that involves "diagnosing ecological becomings and facilitating the invention of new becomings" (Mickey, 2014: 29-30; see also Connolly, 2011: 162). The work of synthetic intuition, imaginative rationality, and the seer can be considered necessary prerequisites to the "intelligence of complexity" of which Edgar Morin speaks (Morin, 2006), a vital yet hazardous undertaking that "may sacrifice precision for accuracy" in its effort to grasp the Planetary Problematic's qualitative complexity (Calvin & Bond-Lamberty, 2018: 2). Yet it does not simply proclaim the superiority of "general" over "restricted" complexity, or qualitative over quantitative methods; rather it recognizes the insufficiency of both taken alone and the need for a productive synthesis (Williams, 2017). This is both the promise of Planetary Assemblage Theory, which responds to calls for a "radical recasting of the dualistic ways" that researchers think about the interactions between political-economic and ecological systems in the Anthropocene (Brondizio et al, 2016: 319), as well as its challenge.

Conclusion

The foregoing concepts will enable us to undertake a more systematic and synthetic analysis of the planetary crisis convergence in the next chapter, one that is to some extent (and unavoidably) speculative, though this speculation is grounded in quantitative analysis of contemporary trends in the earth system, global economy, energy depletion, and food systems, alongside qualitative analysis of political-economic patterns, technological change, subjectivity, and counter-hegemonic resistance. However, while the analysis undoubtedly reflects my own (white, male, North American) individuating perspective and thus my own evaluations of relevance, it is possible to use the framework and/or concepts just described in order to develop different analyses that foreground different dimensions, focus on more localized problematics, and/or come to different conclusions. Thus I believe PAT can stand on its own as a productive framework for understanding and responding to the 21st century Planetary Problematic, though one may disagree with the specific analysis and conclusions drawn in the next chapter.

Chapter Six: An Intensive Mapping of the Planetary Problematic

This chapter will deploy the framework developed in the previous chapter to provide an intensive mapping of the Planetary Problematic and overview of its solution-space. As described previously, the Planetary Problematic can be understood as the 21st century "matrix of individuation" through which actualized modes of collective individuation and the world-assemblage as a whole must pass, and from which new modes and (perhaps) a new world-assemblage will be born. In chapter one I gave an empirical overview of many key dimensions of this problematic, which will be briefly reviewed here. But this chapter will weave these dimensions together in a more synthetic analysis by emphasizing their "dependency relations", or the way in which they all move together – some via tight feedbacks, and others via looser and more indirect relations. Modes of collective individuation and any new world-assemblage must necessarily respond to all these dimensions simultaneously, whether in a planned or ad hoc manner, and we therefore focus on dimensions in isolation from the others at our own peril. By foregrounding these feedbacks, we will then be in better position to illuminate the Planetary Problematic's "solution-space", or the multiple possible trajectories down which the world-assemblage may evolve in response to these converging crises.

While the Planetary Problematic is thus an ontological whole, as noted in the previous chapter I will distinguish it into three relatively autonomous but reciprocally determining problematics: the Socioecological Problematic (SEP), the Molecular and Molar Violence Problematic (MMVP), and the Existential Problematic (EP). Due to limited space, as well as the sheer difficulty of trying to follow all these key parameters simultaneously (not for want of trying), I will give less attention to the EP in this chapter. Rather than giving it an entire section to describe its key parameters and their dependency relations, I will instead integrate it as a dimension of both the SEP and MMVP, showing how transformations in cognitive-affective assemblages will shape and constrain the development of solutions to the SEP and MMVP.

One of the key questions this chapter will investigate is whether the capitalist world-assemblage, given its reproduction requirements and structural constraints, can survive the planetary crisis convergence, or whether the latter will inevitably force a catastrophic bifurcation beyond it. In this sense, we should ask, following Daniel Smith: "What can [global capitalism] tolerate or support? What are the processes that exceed its capacities for reproduction, and put it into question? When does it pass its limit and enter into a new threshold of consistency?" (Smith, 2018: 241). In the terms of Istvan Meszaros, this means understanding the "intrinsic or absolute limits…the established order's *structural parameters*…which cannot be transcended without changing the prevailing mode of control into a qualitatively different one" (Meszaros, 2014: 80; emphasis added). In other words, following Marten Scheffer, if we understand resilience as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks", the question is at what point we can say that the capitalist world-assemblage, along with the modes of collective individuation that it integrates and constrains, has undergone a fundamental shift in its structure, identity, functions and feedbacks (Scheffer, 2009: 105).[130] I will in this sense argue, following Wallerstein (Wallerstein, 2004, 2011), that the planetary crisis convergence *will* most likely provoke a catastrophic bifurcation beyond global capitalism during this century. This does not mean that

[130] Marxists sometimes have trouble concretely answering such questions, since their framework foregrounds totalities and has difficulty conceptualizing the messy hybrid formations that form in the vicinity of systemic transitions (hence unending debates over whether 16th to 18th century Europe was "really" capitalist), but their insights point us in the right direction. While capitalism has been characterized by continuous adaptation and revolutions in the forces of production, it is premised on a more-or-less stable configuration of class relations and organizing principles of the economy. Using Delanda's terminology (in ways he would clearly disapprove), we could say that asymmetric relations between capitalists and workers (broadly defined), in which the former control what gets produced, where, and how much, and economic organizing principles based on private profit and continuous compound growth, form the primary "structural invariants" of capitalism, which remain relatively stable even as capitalism undergoes technological, geographical, governmental, and subjective transformations (Delanda, 2016: 113). The profit-motive, whose dominance is secured by the hegemony of the capitalist class, alongside the exploitation of labor-power, has historically been the engine of the capitalist system: what gives it its identity, structure, and functions; in other words, its creativity, dynamism, cycles of boom and bust, intensification of inequality, and entropic relation to the earth system. Of course labor-capital relations are not static, with intersectionally mediated forms of class struggle able to redistribute income and political-economic power to varying degrees, while the profit-motive has been constrained and harnessed to different degrees by social democratic institutions. Still, capitalist control of the production process and the *dominance* of exchange-value (rather than social use-value) considerations in organizing the economy are like a "threshold" that capitalists seek to ward off (as seen in the post-war Keynesian labor-capital settlement, as well as contemporary Nordic social democracies). There are difficult interpretive issues in determining precisely when such a threshold has been crossed – when has the hegemony of capital and exchange-value as the dominant form of socioecological reproduction been sufficiently constrained or overturned? But the key reason for considering it a *threshold* is in emphasizing the negative feedback mechanisms inherent in the system that ward it off, and the likelihood of a "symmetry breaking cascade" producing a novel set of socioecological relations, feedbacks, and collective individuation capacities should this threshold be crossed (Delanda, 2016: 140).

progressive post-capitalist scenarios are the most probable (Techno-Authoritarian and Collapse scenarios are more likely), but it does mean, as Wallerstein claims, that the "viability of agency" for counter-hegemonic movements will increase, and we should not therefore discount the possibilities for progressive eco-social transformation (Wallerstein, 2011).

To understand why the capitalist world-assemblage is indeed losing its resilience and approaching a catastrophic bifurcation, in the sense that it can longer restructure itself while preserving its core functions (in particular: endless capital accumulation) and feedbacks (in particular: the subordination of labor to capital and ecological dominance of economic growth vis-à-vis other systemic goals) (Meszaros, 2014: 81), it is necessary to map the relations and feedbacks between the multiple crises that constitute the Planetary Problematic. To do so, I will begin by focusing on the structure of the SEP, which will first elaborate its key parameters and their dependency relations (particularly the bidirectional couplings between key parameters) and also show how it is entangled with the EP and MMVP. Next, I will suggest a (by no means exhaustive) set of possible crisis trajectories that could push neoliberal hegemony towards a critical transition, and will then provide a rough outline of alternative possible solutions/attractors that would then most likely emerge at the world-assemblage scale, which can be distinguished according to Green Neo-Keynesian, Ecosocialist, and "Collapse" attractors. Next, I will provide a parallel analysis of the MMVP, though I will primarily focus on the structure of the MMVP that correlates with the "Green Neo-Keynesian" solution, since this could be considered the most "continuationist" solution to the SEP, and we must therefore understand how it will shift problems onto the MMVP in ways that would likely still provoke an overall world-assemblage discontinuity. I will elaborate the dependency relations between the key parameters of the MMVP – including the multiple sub-dimensions of technological change, cognitive-affective assemblages, state securitization, and the intensity of structural violence – and consider possible crisis trajectories and thresholds of qualitative change. I will conclude with an overview of the solution-space of the MMVP that correlates with each solution to the SEP, which can be summarized as a Planetary Techno-Leviathan (which would correlate with either a "Green Neo-Keynesian" or "High Tech/High Throughput Ecosocialist" solution), decentralized security assemblages (which would correlate with an "Ecosocialist Degrowth" solution), or a neo-medieval/feudalist arrangement of securitized bunkers and survivalist formations (which would correlate with a "Collapse" scenario).

The Socioecological Problematic

As described in the previous chapter, the SEP refers to the problem of producing and reproducing the material-energetic and technological conditions of human life alongside its preindividual geological-biological-ecological-climactic milieu, which resolves itself in the form of metastable socio-ecological assemblages. We must emphasize the spatiotemporal and intersectional unevenness of the contemporary SEP, since we are not dealing with a totalizing world-system but rather with multiple scales of relatively autonomous modes of collective individuation with their own distinctive problematics and evaluations of relevance. I will, however, for the most part focus on the emergent planetary scale of the SEP, both for reasons of limited space and due to my limited (white, male, North American) individuating perspective and corresponding evaluation of relevance, though I will also speculate on possible critical transitions in key nodes of the world-assemblage that could generate a global-scale crisis.

Key Parameters and Dependency Relations

In order to develop a synthetic multi-dimensional analysis of the SEP we must begin in a way analogous to dynamic system models. That is, we first identify the most relevant parameters of the assemblage under investigation, then determine their relations and feedbacks, and finally "compute" multiple possible trajectories (Delanda, 2016). Of course, the synthetic crisis mapping in this chapter follows a more qualitative methodology based on synthetic intuition and thick description of key feedbacks between parameters (rather than quantifying them through differential equations), but it is also informed by quantitative studies of key parameters and their bidirectional couplings. Once we understand these dependency relations and feedbacks, we can then develop a set of possible scenarios/trajectories by asking various "what if" questions. For example, what if oil depletion poses critical shocks to the global economy before renewable energy is able to sufficiently expand? On the other hand, what if rising production from unconventional oil prevents critical shortages? What if climate change produces "X" effects on global food security and financial stability by 2030, 2040 or 2050? What if technological breakthroughs enable rapid and massive up-scaling of renewable energy smart grids, net emissions technologies, climate smart agriculture, and other "green" technologies between 2020 and 2040? What if psychosocial tipping points generate massive labor and environmental justice movements across key nodes of the world-assemblage between 2020 and 2030, and what if they don't?

In this way, analogous to the Club of Rome's World3 Model and contemporary Integrated Assessment Models, we can develop possible trajectories for the SEP that are *coherent* in the sense of respecting the dependency relations between key parameters while accounting for variations in these parameters (Delanda, 2016). Of course, given the qualitative nature of the enterprise and my limited cognitive resources (i.e. the fact that I'm not a computer), I cannot possibly account for most (let alone all) potential trajectories, and maintaining coherent dependency relations between numerous parameters is a major challenge in the absence of determinate quantitative relationships that can be modeled and computed via differential equations. But this chapter will at least show *how* such a synthetic multi-dimensional analysis might proceed, and it will focus on what I take to be the most crucial parameters, feedbacks, and possible trajectories of the planetary problematic.

For purposes of analytic traction, the key parameters I will focus on include global climate, food, energy, and financial assemblages, though these form a lower-dimensional snapshot of a higher-dimensional global socio-ecological assemblage combining the multiple sub-systems of the earth along with multiple sub-systems of the global political economy. Each of these assemblages and sub-assemblages in turn can be mapped in terms of key parameters and their dependency relations, some of which are relatively easy to quantify, while others are difficult or impossible to quantify (but no less real for that). For the earth system as a whole, the nine planetary boundaries discussed by Rockström and colleagues (which include climate change, biodiversity loss, freshwater use, ocean acidification, biogeochemical flows, land-system change, chemical pollution, aerosol loading, and ozone depletion); along with important geological conditions (e.g. the distribution of oil, coal, gas, and mineral reserves) could be considered key parameters. However, the most relevant for our purposes are climate and the geology of oil availability, since (following Liebig's "law of the minimum"[131]) these are the parameters most likely to impose near-term constraints and potentially force a catastrophic bifurcation for the world-assemblage as a whole (though possible mineral constraints on the renewable energy transition are also important to consider) (Ophuls, 2012: 10; Capellan-Perez et al, 2019). For the capitalist world-assemblage and its key sub-assemblages of food, energy and finance, we can identify economic growth, food production (and corresponding prices), energy production (and corresponding prices, with primary emphasis on oil[132]), population, unemployment, and total debt as key quantifiable parameters. In cognitive-affective assemblages, difficult to quantify yet crucial parameters for global capitalist stability include phenomena like "investor confidence" and "consumer confidence". While less directly related to economic stability, other parameters like rates of depression and other mental health problems, "belief in the future", "perceptions of legitimacy", and "ideological adherence" to

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[131] As explained by William Ophuls: "the factor in least supply is controlling" (Ophuls, 2012: 10). Thus abundance in other resources may not matter insofar as there are constraints in certain critical resources. However, in the contemporary context this is admittedly a complex issue. While "perfect substitutability", as assumed by neoclassical economists, is far from being a reality, there is *limited* substitutability for certain resources. For example, oil constraints can be substituted by liquefied coal, which may enable circumventing oil shortages or at least making them less catastrophic than often assumed by peak oil theorists (see Randers, 2012). However, some counter this by claiming that the EROI of liquefied coal is too low to serve as an effective substitute, and that it would take significant global scale coordination to enable such a substitution in practice, which could be made more difficult in the event of a major global crisis triggered by oil supply shortages (Bardi, 2017: 94).

[132] It is worth noting that even the oil parameter is itself internally differentiated, with different varieties used for different functions (with the main differences being "light" and "heavy" grades). Energy analyst Antonio Turiel argues that peak production will first be reached with heavy grade oil (e.g. diesel), which is already causing problems for the shipping industry, whereas the light fraction that produces gasoline is less likely to peak in the near term. This is because diesel requires heavy conventional oil, whereas lighter grades of unconventional oil are less suited to its production (Turiel, 2018).

neoliberal values among workers and consumers (e.g. belief in the value of economic growth, privatization, free trade, competition), are important for mapping underlying shifts in cognitive-affective assemblages that may facilitate the emergence of post-capitalist modes of collective individuation.

The key then for mapping the world-assemblage scale of the SEP is to understand the dependency relations between these critical parameters, and then to anticipate potential thresholds at which quantitative shifts in these parameters and state variables could cascade into a catastrophic bifurcation for the capitalist world-assemblage as a whole. Such a bifurcation would be preceded by catastrophic bifurcations in local, national, and regional scale assemblages (whether in the form of local breadbasket failure, oil-field depletion, debt crisis, political-economic "revolution" in key states, or "state failure"), but it is also possible to identify world-assemblage thresholds that emerge from but are irreducible to local, national and regional thresholds, and which would provoke and accelerate catastrophic bifurcations in lower-level assemblages if crossed. Just as the planetary boundaries framework maps a complex geography of entangled local, regional and planetary scale thresholds in the earth system (Steffen et al, 2015), so can we do the same for the capitalist world-assemblage, though such an enterprise can only be speculative, based on a combination of data and intuition, and subject to constant revision as new information comes to light and events in the world unfold – hence the need for a Deleuzo-Guattarian "minor scientific mapping".

I will now describe the key feedbacks within the earth system, and will then discuss the key bidirectional feedbacks between climate, food, energy, and financial assemblages.

The Earth System

As we saw in chapter one, the earth system already appears to be nearing a catastrophic bifurcation driven by feedbacks between its multiple components (Lenton et al, 2019), though this is impossible to quantify with any certainty. However, we can anticipate that the multiple parameters of the earth system will move together through a complex web of dependency relations, and that thresholds are likely in both local ecosystems and the earth assemblage as a whole that would *rupture* these relations and unleash a set of positive feedbacks that reorganize the earth system in a radically different state. Johan Rockström and colleagues in this sense warn that these feedbacks are pushing the Holocene earth towards a “Hothouse Earth”, for which they suggest a likely threshold of 2°C (since this would likely activate important tipping elements) (Steffen et al, 2018: 3). For example, climate change drives biodiversity loss (e.g. deforestation driven by beetle epidemics and wildfires) and arctic ice melt, which then amplifies the rate of climate change by turning forest ecosystems from carbon sinks into sources and diminishing the earth’s albedo, which may subsequently drive further forest collapse, permafrost melting, and carbon and methane release. As we saw in chapter one, many of these components have already reached or appear to be reaching an irreversible tipping point (University of Leeds, 2020; Lovejoy & Nobre, 2018; Baccini et al, 2017; Tagesson et al, 2020). As Tim Lenton warns, this could generate “domino dynamics” in which thresholds in certain earth system processes increase the probability of crossing thresholds in other processes and sub-systems are likely. He writes: “from limited information, it appears that the majority of connections will reinforce each other”

(Lenton, 2013: 34-35). Rockström and colleagues also argue that "if one boundary is transgressed, then other boundaries are also under serious risk" (Rockström et al, 2009: 474), though they emphasize that critical thresholds in biodiversity loss and climate change are the really key parameters that could catalyze an earth system phase shift, while crossing the other boundaries "may predispose the transgression of a core boundary(ies), but [do not by themselves] lead to a new state of the Earth System" (Steffen et al, 2015: 7).

Climate ←→ Energy

The feedbacks between climate and energy assemblages are the most straightforward (at least the energy → climate feedback), with energy consumption constituting the primary feedback driving the earth system towards a "Hothouse earth". Fossil fuel consumption in the form of coal, oil, and natural gas is responsible for about 60% of global greenhouse gas emissions. Rough estimates are that 80% of fossil fuel reserves will need to be kept in the ground to meet the 2°C target, which would likely require halting all new fossil fuel infrastructure by 2020 at the latest (unfortunately, 1,900 new coal projects *alone* are still being planned, which will likely put us on pace for 3.5-4°C or more by 2100) (Smith et al, 2019; Oldridge, 2019; UNEP, 2019). The shift to biofuels in response to peak oil fears and demand for "low-carbon" fuel sources is another energy feedback on climate by driving deforestation in many parts of the world, which destroys biodiversity and turns forests from a carbon sink to source. Even renewable energy will have non-negligible climate impacts, at least in the early stages when fossil fuels are needed to manufacture and transport solar panels and wind turbines

(Friedrichs, 2013; Heinberg & Fridley, 2016; Sole et al, 2018). It is therefore necessary to estimate the minimum level of fossil fuels that will be needed simply to transition to a renewable infrastructure, which will eat further into the already limited carbon budget (and may require rationing) (for estimates see Bardi & Sgouridis, 2017; Schwartzman & Schwartzman, 2018; Sole et al, 2018).

The climate → energy feedback is uncertain and likely less significant, though it still has the potential to provoke or at least exacerbate energy shortages. Other than motivating political-economies to transition to renewable energy, climate change will intensify extreme weather with the potential to damage energy infrastructure and disrupt global energy markets. The Gulf Coast region in the US will be particularly significant, since it has the "single largest concentration of oil-refining capacity in the United States" – 44% of the country's total – and will be highly vulnerable to flooding events and ocean surges during hurricanes (as we saw with Hurricanes Katrina and Harvey) (Blackburn & Jaffe, 2019: 13). Scholars of the "food-water-energy" nexus have also emphasized how energy production relies on water, which means that the intensification of drought driven by climate change may become a constraint on energy projects (Rosa et al, 2018). D'Odorico et al note that new technologies being implemented to decarbonize the economy – including biofuels, concentrating solar power, and carbon capture and storage – are highly water-intensive, which means that "water availability may challenge existing energy operations" (D'Odorico et al, 2018: 479).[133] Nick Cunningham shows that water scarcity is already becoming a (under-remarked) problem for the water-intensive US shale industry (Cunningham, 2019), while others argue that this could limit the potential

[133] Climate change-induced drought also diminishes hydropower potential. We see this in Venezuela, where drought has reduced water levels in key reservoirs needed to run hydroelectric power generators, forcing drought-stricken states to ration electricity (Polanco, 2018).

for shale oil and gas exploration in China, since China is already in the throes of a water crisis (Wang et al, 2017). Renewable energy overall is estimated to require less water than fossil fuels, but will still require a steady input for cleaning and cooling purposes (especially for concentrating solar power), which may then put further demands on energy infrastructure if water needs to be shipped to deserts (e.g. in the case of Desertec) or drought stricken regions. Climate will also feedback on energy assemblages by increasing demands for air conditioning and refrigeration, which one study estimates could increase energy demand 25-58% by 2050 *on top of* projected expansion due to economic growth (Van Ruijven et al, 2019). Finally, it is possible that climate change could reduce the global potential for renewable energy by increasing cloud cover and reducing wind energy, though there is great uncertainty in how these components of the earth system will evolve in response to climate change.[134]

Climate ←→ Food

The climate-food nexus may be the most significant in terms of its impact on human security and political-economy stability, and global food assemblages are a primary driver of climate change. First, world agriculture is the prime culprit in fueling the overshoot of at least 5 of the Earth's 9 planetary boundaries: 1) most importantly, climate change, since it constitutes the single largest source of greenhouse gas emissions (35%), mainly due to tropical deforestation, methane released from animals and rice paddies, and nitrous oxide released from overfertilized and tilled soils, but also from the

[134] Some researchers anticipate that climate change will reduce wind power in the global north, which will lower the overall potential for wind energy in these regions (Damon & Moriarty, 2016). Increased cloud cover could also reduce the potential for solar energy (ibid), though it is unclear what effect climate change will have on clouds. Certainly if geoengineering schemes like solar radiation management are adopted then the potential for solar energy will be compromised, which could then form an unanticipated positive feedback on the climate system.

fossil fuels used to grow, process and transport food (Foley, 2011); 2) the nitrogen and phosphorous cycles, since these are critical inputs that have been over-taxed by the capitalist "fertilizer treadmill", leading to shortages and run-off from farms that drives water pollution and biodiversity loss in the oceans and rivers (Clark & York, 2012); 3) land use, since "agriculture has already cleared or radically transformed 70 percent of the world's prehistoric grasslands, 50 percent of the savannas, 45 percent of the temperate deciduous forests and 25 percent of the tropical forests" (Foley, 2011: 62); 4) the hydrological cycle, since 70% of world water use is for irrigation (Brown, 2012: 57); and 5) biodiversity, since land use change and the dominance of monoculture farms reliant on pesticides and herbicides degrade the life-supporting potential of agro-ecosystems. Thus many conclude that the global food system will need to be radically transformed in order to prevent runaway crossing the climate and other planetary boundaries. In particular, recent studies from *The Lancet* argues that this will require full decarbonization of the food value chain by 2050, no new land-conversion while feeding humanity on existing agricultural land, a "Half Earth" strategy that protects 50% of Earth as intact ecosystems, reduction of food waste by 50%, and meat consumptions reductions of 90% in the global north (Willett et al, 2019; Springmann et al, 2018).

Climate change in turn will have potentially devastating impacts on food production, though there is great geographic variation and uncertainty. The IPCC's 2018 report shows that temperature and precipitation trends have already reduced crop production, with the most negative impacts felt on wheat and maize yields. It projects that, for each degree celsius of temperature increase, wheat yields will be reduced between 2.9 and 6%, rice by 3.2-3.7%, maize by 4.5-7.4%, and soybeans by 3.1% (IPCC, 2018: 236).[135] Some studies predict that the increasing feasibility of agricultural production in the boreal regions of the north could offset losses elsewhere, though increasingly unpredictable weather patterns and non-linear shifts in the climate system, alongside biodiversity losses, will pose significant challenges to agriculture regardless of temperature (ibid). Intensified drought will also have critical implications that aren't factored into the IPCC's above calculations: 20 to 30% of the earth's total land surface is projected to become stuck in "permanent drought" by 2050 under a 2°C scenario (Park et al, 2018), while key growing regions like California are expected to "whipsaw between drought and flooding" (Swain et al, 2018). IPCC projections also don't account for accelerating losses in insect populations, especially bees, which means that one of the key ecological dimensions of agricultural sustainability is being eroded, while the reduction of agro-biological diversity across the globe means that existing crops are very vulnerable to diseases and pests that can "sweep through large areas of monocultures" (Carrington, 2019). Increases in climate extremes – e.g. rainfall extremes, heat waves, and flooding – will also have detrimental but difficult to predict impacts on food production (IPCC, 2018: 237).

Overall, studies suggest that "crop yields will have to keep increasing (doubling between 2005 and 2050) in order to meet the increasing demand for agricultural products" (D'Odorico et al, 2018: 503). However, Challinor et al, analyzing data from over 1,700 models, demonstrate "a majority consensus that yield changes will be negative

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[135] In regards to fisheries, climate change is not expected to have as deep an impact as on agriculture, though the degradation of aquatic ecosystems like coral reefs, seagrass and mangroves, coupled with non-climate stresses (e.g. pollution, overfishing, coastal development) are already driving many small-scale fisheries "well below the sustainable harvesting levels required to maintain these resources as a source of food" (IPCC, 2018: 237). Again the IPCC reports much geographic variation, with many northern latitude fisheries expected to witness increased fish yields due to fish migrating north. But overall they project likely decreases by more than 3 million metric tonnes for each degree of warming, and models suggest that global trends will lead to shortages of fish protein in the Pacific and Indian oceans later this century (ibid: 237-238).

from the 2030s onwards" (Challinor et al, 2014: 289), suggesting that meeting growing demand will be a huge political-economic and technical challenge, and that global food system shocks may happen sooner than many analysts believe (Ahmed, 2019a).

Climate ←→ Finance

The feedbacks between climate and the global financial system are highly uncertain, complex, and very significant (especially the finance → climate feedback, which is the primary driver of and constraint on resolving the earth system crisis). The economic impacts of climate change will likely include capital shifted from production to infrastructure repair and adaptation, increasing health care costs, dampened consumer and investor confidence due to uncertainty about the future, and diminished labor productivity (particularly for outdoor workers) (Bolton et al, 2020). There is great uncertainty concerning projected total damages in different mitigation scenarios, though many believe they are currently being under-estimated in most Integrated Assessment Models (e.g. Nordhaus, 2013) – due mainly to their inability to represent potential tipping points in earth and human systems, ignorance of how climate impacts will feedback on economic growth, and assumption that losses from climate impacts are perfectly substitutable with increased consumption and can be fully compensated by higher incomes (Diaz & Moore, 2017). Taking into account the feedbacks on economic growth, Marshall Burke and colleagues estimate that a 2.5-3°C temperature rise by 2100 would reduce per capita output by 15-25% relative to a world without warming and by more than 30% with 4°C warming, though even these projections don't account for tipping points (Burke et al, 2018). Then there are also the (poorly understood) potential impacts on financial instability from large hits to the insurance industry in the case of unprecedented socio-natural disasters, as well as the impacts of stranded fossil fuel assets (to be discussed further below). There is much uncertainty on whether and how these devaluations would feedback on and potentially pose systemic risks to the global economy as a whole. But as Mark Carney warns: "a wholesale reassessment of prospects, especially if it were to occur suddenly, could potentially destabilize markets, spark a pro-cyclical crystallization of losses and a persistent tightening of financial conditions" (Carney, 2015), or what some refer to as a "Climate Minsky moment" (NGFS, 2019: 17).[136] The longer we delay (i.e. precisely what governments and financial institutions are doing at the moment) the higher the risk such a destabilizing transition becomes.

Regarding the finance → climate feedback, the hegemony of exchange-value considerations and the capitalist growth imperative are ultimately the main drivers of rising material-energy throughput and the resulting earth system crisis, and the financialization of global capitalism under neoliberalism has only intensified these trends.[137] For one, the deregulation of debt-money creation exacerbates the growth imperative by requiring economy-wide growth in profits to pay off accumulated debts (Pettifor, 2017). The threat of capital flight and "bond market vigilantes" also constrains governments from enacting the needed spending increases to overhaul energy

[136] Bovari et al develop an Integrated Assessment Model which shows that very high carbon prices in the short term can limit climate change to 2 °C, though it would be "achieved at the cost of a deep worldwide economic recession". Their model suggests that a more moderate carbon price that wouldn't catalyze economic recession (which would increase to $44 in 2020, $140 in 2030, and $300 in 2040) would enable a 2.5°C C objective in 2100 (Bovari et al, 2018: 393). This may constitute a genuine resolution of the SEP (from the perspective of capital), though it doesn't account for earth system feedbacks that would likely push temperatures well beyond 2.5°C.

[137] Some would say that the financial system can also contribute to climate protection, e.g. through the creation of "green bonds" that finance environmentally beneficial development projects. This market grew from US $11 billion in 2013 to $36.6 billion in 2014 (Galaz et al, 2015). But oversight of these projects to ensure their environmental benefits remains weak, and it remains likely that the majority of these projects involve trade-offs that exceed their environmental benefits (ibid). In other words, as Patrick Bond argues, they are an example more of "shifting, stalling, and stealing" rather than generating the needed socio-ecological transition (Bond, 2012).

infrastructures, thereby entrenching austerity. On other hand, financial crises slow climate change be reducing economic activity, thereby reducing emissions. However, as we saw in the wake of the 2007-08 crisis, government priorities to "restore growth at all costs" had a debilitating impact on climate policy, seen in the dismal outcome of the 2009 UN Climate Change Conference in Copenhagen (Rockström & Wijkman, 2012: 2). Thus future financial crises (which are practically assured, as we saw in chapter one) may further exacerbate climate change as slowing profits, depressed consumer spending, and rising unemployment pressures governments to focus on economic growth by any means necessary ("green" or otherwise), though it could also create the necessary conditions to break through neoliberal hegemony towards a "global green new deal" (Dawson, 2010; Aronoff et al, 2019; UNCTAD, 2019). So in general the financialization of neoliberal life-support assemblages propagates social and ecological entropy, but the instability it provokes could potentially enable more progressive changes (though as we've seen, neoliberalism can also thrive from its own crises, creating opportunities for disaster capitalists and redistribution of assets to wealthy corporations and asset managers) (Klein, 2008; Loewenstein, 2017).

Food ←→ Energy

Food → energy assemblage feedbacks are indirect and unlikely to be significant, though agricultural shocks in biofuel-producing regions can raise ethanol prices (Newell & Lane, 2018). Further, food security experts warn that food shortages in key oil exporters like Saudi Arabia could lead to oil production cuts to raise prices and secure finance for imports and subsidizing domestic food production, thereby contributing to oil shocks (Maynard, 2015: 17).

Energy → food feedbacks are more critical. The dominant global agri-business model is critically dependent on increasingly scarce fossil fuel supplies in all its phases – from machinery used on the farm to processing, packaging, refrigeration, and transportation. Energy supply shortages thus directly contribute to food price spikes (as in 2008) while also creating the threat of a supply chain choke (or even breakdown) in the case of another mutually reinforcing energy-economic crisis (Ahmed, 2017; Homer-Dixon et al, 2015).[138] Growing demand for biofuels also displaces agricultural land used to grow food, thereby contributing to food price rises. The same is true with proposed "bioenergy with carbon capture and storage" (BECCS) plans, which are among the most commonly promoted technological solutions to climate change. If such proposals are adopted on a wide scale, they would also compete with land use for food production and thus likely exacerbate food insecurity (Willett et al, 2019: 17; Smith et al, 2016; IPCC, 2019).

Food ←→ Finance

As we saw in 2008, capitalism's crises not only depress spending power among precarious workers and enhance food insecurity but have also contributed to financial speculation that intensifies already volatile food price movements as well as the recent wave of land grabbing throughout the global south, since food and land constitute

[138] In crisis-cascade section should mention their entwinement with the problem of non-state violence, since supply chain disruptions through sabotage or bioterror attacks pose significant risks to global food systems organized at the behest of free market principles and agribusiness interests at the expense of considerations of resilience and security (Homer-Dixon, 2002).

relatively "safe assets" that ensure profitability in turbulent times (GRAIN, 2010; Homer-Dixon et al, 2015). The finance driven global land grab is also leading to rising prices for farmland, which puts pressure on already precarious small and medium scale producers and makes it more difficult to transition to alternative practices. As Clapp and Isakson document, speculative farmland investments have also encouraged production increases at all costs, employing industrial farming methods that fuel climate change and biodiversity loss. They describe how agribusiness restructuring driven by the shareholder revolution has had the effect of "locking in reliance on a shrinking array of genetically modified seeds and associated agrochemicals, with deleterious effects on biodiversity and attendant knowledge and practices" (Clapp & Isakson, 2018: 18-19). Financialization also elongates fossil-fuel based global supply chains by pushing agribusiness firms to outsource production and processing to where labor is cheapest and environmental regulations are weak, and it reinforces the dogma of "free trade" by strengthening the market power of low-cost industrial producers (ibid: 15). As noted in chapter one, this weakens the resilience of the global food system by concentrating production specific regions while undermining the food self-sufficiency of many countries (mostly in the global south) (Janetos et al, 2017). Crop failures in key regions would therefore have unpredictable global systemic repercussions.

Regarding the finance → food feedback, it is possible that agricultural crises in response to drought, pest outbreaks, or severe weather damage could generate global financial and economic instability by catalyzing debt defaults among farmers and raising food prices, which could ripple through the economy by depressing consumer spending and hurting profits. Following Jason Moore's argument that global capitalism requires "cheap food" in order to reproduce itself by keeping wages low, global reductions in agricultural yields and price spikes would severely test the stability global capitalism, though it is questionable whether they would catalyze a major political-economic crisis before killing thousands or more.[139]

Energy ←→ Finance

Despite the increasing abstraction of financial accumulation and its apparent decoupling from the "real economy", the stability of the financial system (and global capitalism more generally) is ultimately reliant on continuous streams of energy and functioning global energy markets. Nafeez Ahmed, David Murphy, Tim Jackson and others show that a long-term decline in the rate of economic growth is correlated with the half-century trend of net energy decline, while energy price spikes have been clearly correlated with financial crises and recessions (including the 1970s and 2007-08 crises) (Ahmed, 2017; Murphy, 2014; Jackson, 2018). Economic growth thus closely correlates with increases in energy consumption, and while there has been modest *relative* decoupling (which may be attributable more to historically cheap credit and high levels of debt rather than genuine efficiency gains), so far there is no evidence for the possibility of *absolute* decoupling of economic growth from energy use (Kallis & Hickel, 2019; Parrique et al, 2019; Ward et al, 2016). Thus shortfalls in energy supply have critical impacts and can fuel financial crises, as they did in 2008 when plateauing conventional oil production combined with rising demand from China and India sent oil prices

[139] Andreas Malm critiques Moore for focusing on the impacts of agricultural crises on global capitalism while downplaying the immense human cost that they would likely have before have significant systemic consequences. In this sense, he believes that if rising food prices cause profits to plunge, there will do so "long after famines have killed off millions", with no impact on global processes of capital accumulation (Malm, 2018: 193).

skyrocketing, thereby making it more difficult for home-owners to service their debt and contributing to defaults that fed back into the financial system (Homer-Dixon et al, 2015; Thompson, 2017).

On the other side, the financial system is itself a key enabler of the fossil fuel industry, not only bankrolling many of the world's leading fossil fuel companies but also funding exploration of shale oil and gas, pipelines, and other fossil fuel infrastructure projects. In open defiance of the Paris Agreement, 33 global banks have given $1.9 trillion to fossil fuel companies since 2015, with JP Morgan Chase, Wells Fargo, Citi and Bank of America forming the worst contributors (Rees, 2019). Unconventional oil producers in particular rely on finance, since it is expensive to develop and requires experimental technologies and continuous innovation. Thus financial crises can constrict credit to these industries and make it more expensive for them to service their debt, thereby crippling these industries (Ahmed, 2017). This may have further knock-on effects for financial stability and the economy as a whole, though it could also contribute to slowing climate change and facilitating the renewable energy transition. More positively, many believe that a finance-driven renewable energy transition is possible that would "shift the trillions" from fossil fuels to renewables (IEA, 2017). It is true that the fossil fuel divestment movement has gone increasingly mainstream, with influential hedge funds and city governments choosing to completely divest from fossil fuels, while initiatives to force corporations to disclose their climate-risk exposure (both from direct physical impacts and stranded fossil fuel assets) are gaining steam (Leggett, 2017). However, as Bardi & Sgouridis show, the transition remains at least an order of magnitude too slow to meet the Paris Agreement targets, which would need to ramp up investment in renewables from about $330 billion to $3 trillion per year (according to Mark Jacobsen's estimates) (Bardi & Sgouridis, 2017).

Socioecological Problematic ←→ *Existential Problematic*

Before considering possibility trajectories for the SEP as a whole it is worth discussing its feedbacks with the EP. To start, it is clear that, as Jeremy Lent shows, cognitive-affective patterns based on separation from and conquest of nature, with their corresponding faith in the plausibility and desirability of infinite growth, contribute to constraining the SEP solution-space within neoliberal capitalist parameters (Lent, 2017). Such patterns can also be seen in ecomodernist ideologies of both capitalist and socialist stripes, which could certainly facilitate more rational ecological practices relative to our current eco-blind mode of neoliberalism, though they would perpetuate the same modes of collective individuation based on endless growth and separation from/control over nature. Neoliberalized patterns of subjectivation also increase the difficulty of mobilizing collective action to transform fossil fueled socio-ecological assemblages. "Apathy" appears to be rampant, which Bernard Stiegler argues is symptomatic of a generalized "loss of collective individuation" in which most people in rich industrialized countries have difficulty projecting themselves as part of a "we" (Stiegler, 2012). Of course it is also simply due to people struggling under neoliberal precarity, with day-to-day survival taking precedence over political action. What would it take to catalyze a large-scale cognitive-affective transition from apathetic/quietist subjectivities to more "revolutionary" (or at least politicized) subjectivities?

From the other side, crises in the SEP are already in the process of and will continue to catalyze bifurcations in individual subjectivities towards new patterns, which will in turn feedback on the SEP. As Matthew Adams writes, the climate crisis is indeed provoking "existential crises" that "undermine a number of related 'certainties' that have come to provide a taken-for-granted foundation for day-to-day existence", including trust in political institutions, capitalism, consumerism, and liberal democracy (Adams, 2016: 112). We can see this in diminishing support for capitalism among younger populations in the US (Younis, 2019), the explosive growth of climate activist movements (including the Extinction Rebellion movement and "Fridays for Future" strikes), and proliferating forms of "prefigurative" activism engaged in creating low-carbon ways of life – from Transition Towns and Ecovillages to solidarity economies and voluntary simplicity (Hamilton, 2010; Penha-Lopes et al, 2019; Birnbaum, 2014). It therefore appears that crises in the EP are slowly generating new modes of collective individuation based on ecological regeneration, care, and political engagement. However, opposite trends toward religious fundamentalism, exclusionary nationalism, and "molecular fascism"[140] are of course gaining strength as well, largely as a result of the unrestrained excesses of market-based neoliberal rule and its corresponding economic instability and inequality (Connolly, 2017b; Neiwert, 2017). Following Karl Polanyi, just as fascism "responded to the needs of an objective situation" during the 1930s great depression (Polanyi, 1944: 237), so are contemporary crises in the SEP laying the conditions of emergence for

[140] The term is meant to distinguish this phenomena from the "molar fascism" of state regimes, as in Hitler's Germany and Mussolini's Italy. Instead, molecular fascism emerges as a disparate yet self-reinforcing affective landscape in which accumulations of resentment find expression against various minority groups, which could *potentially* lay the psychosocial foundations for the eventual emergence of molar fascism (Deleuze & Guattari, 2004: 236).

fascist "solutions".[141] Joshua Jackson and Michele Gelfand even suggest that climate change may be fueling far-right resurgence by provoking "cultural tightening" among populations whose identities are particularly threatened (Jackson & Gelfand, 2019). They fear this "may create a vicious cycle, in which the threat of climate disaster and far-right nationalism encourage one another over time" (ibid), which would further intensify socio-ecological crises by preventing (or at least critically delaying) the transition to sustainable socio-ecological assemblages. In this way we will likely be witnessing an intensified struggle between exclusionary forms of communitarianism/neo-fascism and ecological and solidarity-based modes of collective individuation in the coming decades.[142] If the latter were the dominant response to crises in the EP, then international cooperation would further breakdown and a global socio-ecological collapse trajectory would become practically assured, though the same existential crises may create the preconditions for widespread "psychological tipping points" in the direction of eco-democratic mobilization from below (Monbiot, 2019). In the case of the latter, if psychosocial tipping points generate revolutionary subjectivities among more than 3.5% of populations in key states – the "critical threshold" identified by Erica Chenoweth for

[141] David Neiwert argues that the Trump phenomena so far should be considered "proto-fascist" rather than fascist, both because Trump does not subscribe to a rigidly consistent ideological program (only worship of himself), and because he has not affirmed his connection to (and called upon the violence of) his neo-Nazi and white-supremacist base. Yet it can be said that "he is simultaneously responding to and creating the conditions that could easily lead to the genuine growth of fascism" (Neiwert, 2017: 365-366). In other words, he is both recognizing and responding to the "objective situation" or problematic that in many ways repeats the conjuncture of the 1930s (with a difference), while facilitating the self-organization of a genuinely fascist solution.

[142] Things are of course more complex, since there are also more exclusionary versions of ecological consciousness (e.g. "ecofascism") that subscribe to a "lifeboat ethics" and corresponding anti-immigrant agenda. For example, Rob Harding from the Millennium Alliance for Humanity and the Biosphere writes: "The paramount problem with the open borders position seems to be its prioritization of social justice to the exclusion of ecojustice — ultimately, there is no possibility of social justice on a dead planet except for the equality found in dying. Societies must first and foremost live within ecological limits" (Harding, 2018). Such views not only subscribe to a problematic Malthusian determinism, but also downplay the barbaric injustice of leaving populations to die who are least responsible for ecological crisis, while those in the rich countries of the global north protect themselves and their way of life. Unfortunately this dispute between climate justice advocates and Malthusian determinists will be a continuing source of tension in the northern environmentalist movement, involving overlapping yet in important ways incompatible understandings of the SEP and its solution-space.

toppling oppressive regimes (Chenoweth, 2017), now popularized by Extinction Rebellion – will neoliberal regimes succumb to demands for a global Green New Deal (and perhaps more radical measures over time)?

Socioecological Problematic ←→ Violence Problematic

Finally, it is important to consider how the MMVP and resulting military-security assemblages may feedback on and constrain solutions to the SEP, while the latter will in turn impact the MMVP in critical ways. First and most importantly, geopolitical tension between nation-states (especially the US, China, and Russia) weakens global cooperation and strengthens the military-industrial complex. Militaries are not only huge sources of emissions (with the US military emitting more in 2017 than many countries, including Sweden) but also massive diversions of human, financial, and material-energetic resources from sustainable development towards death and socio-ecological destruction (McCarthy, 2019). Total military spending worldwide increased to \$1.8 trillion in 2018 (including \$649 billion by the US and \$250 billion by China), equaling roughly 2% of global GDP (SIPRI, 2019). Comparatively, many claim that between 2-3% of GDP will need to be shifted towards renewable energy and efficiency improvements to meet the Paris Agreement targets (with a broader 6-8% of GDP – or \$5-7 trillion annually by 2030 – needed to meet the SDGs) (Bardi & Sgouridis, 2017; GIIN, 2018). David and Peter Schwartzman argue that global demilitarization is therefore "a necessary condition for both robust cuts in carbon emission and a transition to renewable energy on an adequate time scale" (Schwartzman & Schwartzman, 2018: 102). Second, discourses of "terrorism" are also being used to legitimate surveillance, draconian sentencing, and brutal repression of environmental activists (particularly in the global south). Recent years have witnessed a dramatic rise in killings of indigenous and other activists, while the US and UK often define climate activists as "domestic extremists" or even "eco-terrorists" while devoting "enormous resources…to identifying, tracking and spying on them" (Buxton & Hayes, 2015: 12; see also Federman, 2020). Overall, these trends may form a negative feedback on environmental movements aiming to catalyze just solutions to the SEP at local and global scales.

Regarding the SEP → MMVP feedbacks, besides the impacts of high tech/green growth solutions to the SEP (which I will discuss below), it is well known that climate impacts – particularly drought and food insecurity – have the potential to trigger or at least exacerbate inter and intra-state conflict. For example, water scarcity may trigger conflict in Middle East, the Nile river basin or the Himalayan rivers flowing through India and China. While conflict is by no means an inevitable outcome, a future conjuncture of subsistence crises and world order destabilization could make conflict appear less costly and more appealing (Sternberg, 2017). Diminishing access to fish stocks may also fuel conflict between states in contested waters where populations are heavily dependent on fish for their survival, for example in the South China Sea, the Arctic, and the African great-lakes (Thomas, 2017). A combined energy-economic crisis, perhaps exacerbated by supply-chain disruptions driven by conflict or extreme weather impacts, would also likely put pressure on states like the US to engage in acts of aggression towards weaker oil rich states (Friedrichs, 2010).[143] Lester Brown also raises

[143] While we may not see great power conflict in the Middle East or Caspian basin, as Michael Klare warns (Klare, 2007), since energy constraints would raise the costs and risks of geographically drawn out U.S. military operations, it seems more likely that regional conflicts would take place between states looking to make up for domestic shortfalls in oil supply (e.g. between China and India in Central Asia) (Friedrichs, 2013: 106).

the specter of conflict between the US and China as the latter becomes increasingly dependent on (dwindling) American grain exports, while its large holdings of US securities would make it difficult for the US to cut its exports (Brown, 2012: 91-92). Overall, as critics of the climate conflict literature often emphasize (e.g. Selby, 2014; Barnett & Adger, 2007), it is by no means inevitable that climate impacts will drive conflict in these ways, and the risk of conflict may even incentivize states to adopt more cooperative global responses due to the perceived costs of inaction. However, the potential for conflict should not be discounted, and it would form a further negative feedback on the SEP solution space by eroding global, national, and local capacities to catalyze socio-ecological transitions toward sustainability.

Near-Term Crisis Trajectories (Between 2020 and 2035)

The foregoing analysis helps to illustrate the dependency relations between the key parameters of the SEP, which gives us a better understanding, first, of how critical transitions in each parameter may interact with and reinforce critical thresholds in other parameters, thereby catalyzing a crisis and bifurcation for the capitalist world-assemblage as a whole; and second, how solutions to individual parameters that ignore their impacts on others may simply shift problems around – e.g. responding to oil constraints by shifting into unconventional oil or land and water-hogging biofuels, stimulating economic growth while increasing energy consumption and associated earth system impacts, or accelerating emissions reductions while exacerbating financial and economic instability – in this way mitigating one crisis while intensifying others. Foregrounding these relations and feedbacks is therefore necessary both to understand the parametric constraints that the SEP imposes on global capitalism's continued evolution, as well as the possible crisis trajectories that may force it to reorganize (or collapse) in the coming years and decades.

Before discussing potential reorganizations of the capitalist world-assemblage, I will first consider possible shocks and crisis cascades that may catalyze such a reorganization. These crisis scenarios can be roughly distinguished by their key trigger and mechanism of propagation, which may originate in the sub-systems of climate, food, energy, or finance and then propagate through one or more of these sub-systems (e.g. an extreme hurricane triggering a local shock that propagates through food, energy, and/or financial systems). Given the relations and feedbacks in global life-support assemblages, it may be difficult in certain cases to isolate a key trigger; for example, can we clearly say that the key trigger for the 2007-08 crisis originated in the energy or financial sub-system (Homer-Dixon et al, 2015; Thompson, 2017)? The reality is always messy, though in any crisis trajectory it is often possible to roughly distinguish a key trigger and sub-system through which it propagates. As Homer-Dixon and colleagues show, just as we saw in 2007-08, any crisis in one sub-system would then likely cascade outwards into shocks for the other sub-systems (Homer-Dixon et al, 2015), and we must therefore consider these possibilities as well.

Oil Shocks

To start, as "peak oil" theorists have long warned, the growing reliance of global capitalism on unconventional oil and the resulting decline in global net energy levels makes it more vulnerable volatile price swings and supply shocks, which played an important role in triggering the 2007-08 financial crisis (Homer-Dixon et al, 2015; Thompson, 2017). While the risk of near-term supply shocks appears low, given the Covid-19 pandemic and consequent collapse in oil demand, they should not be discounted over the next 5-10 years. For example, even before the crisis the normally bullish International Energy Agency claimed that spare oil production capacity risked being "stretched to the limit" due to insufficient upstream investment (quoted in Whipple & Stevens, 2018). Now with the collapse of investment in discovering and developing new oil fields (which some say would need to involve "Four Saudi Arabias" worth of oil by 2040 to compensate for declining fields) (Michaux, 2019), in conjunction with rising demand as economies recover from the pandemic, the conditions may be in place for a crippling supply shock in the coming years (that is, assuming demand recovers) (Ahmed, 2020b; Chapman, 2020). Mainstream economists would assume that rising prices will simply bring more supply online by incentivizing unconventional production. However, a combination of worsening drought – which, as scholars of the water-energy nexus remind us, can "challenge existing energy operations" (especially in shale oil, which is highly water-intensive) (D'Odorico et al, 2018: 479; Cunningham, 2019) – and political-economic instability in critical oil-producing states like Saudi Arabia, Venezuela, Iraq, Iran, and elsewhere, may undermine this assumption. Both of these factors would, of course, be intensified by climate change, again showing why isolationist approaches to the oil problematic, whether coming from geologists or economists, miss the big picture.

Furthermore, some believe that a collapse in the US shale oil and gas industry may bring (previously premature) predictions of "peak oil" to fruition, since rising global production rates over the past decade have been almost entirely dependent on rising unconventional production in the US (IEA, 2019b). US shale growth already began to plateau in 2019 due to a combination of low prices, reduced funding from impatient investors (who have not received the profits promised by the shale hype), water stress, and rapid depletion of the "sweet spots" [144] (Cunningham, 2019; Hughes, 2018; Berman, 2018), which is only being exacerbated by the Covid-19 pandemic. While a collapse of the US shale industry could remain a relatively localized event, we should not discount the possibility of it triggering dynamics of self-organized criticality that are disproportionate to the initial stimulus. For example, given that expectations of uninterrupted growth in oil production rely on projections of continued growth in US shale, which is expected to "account for 70% of the rise in global oil production" over the next five years (IEA, 2019b), a near-term collapse of this industry could provoke a major "crisis of confidence" in the viability of continued economic growth (Boyd, 2013: 6-7) or at least a shock to the financial system (Al-Hamad & Verleger, 2016; McLean, 2018).[145]

While many hope that rapid advances in renewable energy will come to the rescue well before any kind of irreversible oil shock, the biophysical limits of solar and wind energy discussed in chapter one (primarily its relatively low EROI) means that they will likely be unable to meet the energy needs of a continuously expanding global economy (Heinberg & Fridley, 2016; Capellan-Perez et al, 2019; Moriarty & Honnery, 2016).

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[144] Geologist Arthur Berman anticipates that there are "years, not decades" left of shale reserves in the U.S. Industry promoters expect the two largest shale plays in the US – the Eagle Ford and Permian Basins – to continuously produce high quantities of oil for decades, with the Eagle Ford expected to produce 1.3 million barrels of oil per day (mmb/d) and decline to 1.2 mmb/d by 2050, and the Permian expected to grow from 2.2 mmb/d today to 3.5 mmb/d by 2044 and decline to 3.4 mmb/d by 2050. In contrast, he argues that ultimately recoverable reserves are actually decreasing, with better technology resulting in higher initial production rates but also higher decline rates. He therefore estimates that Eagle Ford reserves will be exhausted at current production rates by 2025, and that Permian reserves will be exhausted around 2022. He acknowledges that discovery of new supplies beyond anticipated reserves is likely, but argues that these could only be developed in a context of near zero-interest rates and massive capital injections (Berman, 2018).

[145] Of course, the US government would likely try to bailout the shale oil and gas industry in this context. However, we have seen today that this has been difficult even under Trump (due to resistance from congressional democrats), and thus there is no guarantee that a bail-out would be forthcoming during a future crisis. And of course a bailout would lead to further problems, not only worsening climate change but also raising the US's already mountainous debt while potentially weakening the legitimacy of the US state.

More worrying, oil shocks risk stopping or slowing the renewable energy transition by reducing the energy available for manufacturing and transporting wind panels and solar panels, along with the minerals on which they rely (Friedrichs, 2013; Heinberg & Fridley, 2016; Sole et al, 2018). Therefore, while many expect that an oil price spike would simply incentivize technological innovation and an accelerated shift towards renewable energy, others who emphasize the biophysical dimensions of the energy transition (i.e. the fact that it takes energy to build an energy infrastructure, as well as water, minerals, and stable supply chains) caution that this may be difficult in crisis conditions (Friedrichs, 2013). Ugo Bardi therefore argues that "we need to increase by about a factor of 50 the amount of energy invested in creating a [renewable] energy infrastructure, and do it now", for the transition to be viable (Bardi, 2017: 163). Of course, this view may over-estimate the likelihood of near-term supply shocks, and technological innovation combined with continued financing from stubborn investors (and/or national bailiuts) may enable unconvential oil to expand despite the headwinds described above, but then we'd simply have an even more dramatic climate crisis on our hands (Global Witness, 2019).

If oil price shocks do materialize they could also trigger food shocks by raising the costs of petroleum-derived inputs for industrial agriculture, and they may further stress food prices if northern states respond by ramping up biofuel production. On the more hopeful side, an oil shock and subsequent recession (possibly depression) would serve as a negative feedback on climate change by reducing overall emissions; hence the view among some "peak oil" theorists that climate change won't reach worst-case-scenario predictions (e.g. Greer, 2008). However, due to inertia built into the climate system, carbon-cycle feedbacks already being unleashed (e.g. methane release, deforestation, and ice albedo reduction), and continued emissions even in a peak oil scenario, it possible that warming would still breach the 2°C threshold. In that case, we would "eventually end up with catastrophic climate change and *no* viable energy system" (Heinberg & Fridley, 2016: 129-130).

Financial Shocks

Oil supply shortfalls in this way have the potential to trigger financial crises both by weakening over-indebted businesses and consumers and/or by feeding a generalized "crisis of confidence". But there are numerous other triggers that could generate financial crises with cascading impacts across the capitalist world-assemblage, with some originating "inside" and others "outside" the global financial system (a relative distinction, given that global finance has in many respects "internalized" the earth system) (Moore, 2015). As discussed in chapter one, the global economy is wracked by record total debt levels (reaching 225% of global GDP in 2017), and some suggest that this places the global economy in a "super-critical" position where failures in one region or sector could cascade across the world-assemblage (Reid et al, 2017; Rickards, 2016: 73-74). Again, "belief" or "confidence" is a critical parameter here, since debt is only sustainable insofar as lenders and investors believe that continued compound growth will enable these debts to be repaid.

Regarding triggers within the financial sub-system itself, numerous analysts identify the Eurozone and China as possible flashpoints.[146] While the Eurozone crisis

[146] Should we also include risks to US dollar hegemony and the potential for a dollar collapse? As Adam Tooze recounts, the "balance of financial terror" between the US and China – created by rising US deficits combined with

from 2010-2014 was largely settled through agreement to formalize the European Central Bank's role as conditional lender of last resort – punctuated by Mario Draghi's "whatever it takes" speech" (Tooze, 2018: 438-441), many like Joseph Stiglitz believe that these were mere temporary half measures that don't address the underlying weaknesses of the Eurozone – most notably the power imbalance between creditor and debtor countries, insufficient adjustment capacities for countries facing a crisis, and ideological commitment to austerity (Stiglitz, 2018). Many worried that a Greek default would trigger contagion to other banks and sovereign debtors across the Eurozone, therefore triggering a wider crisis, while more worry that a debt crisis in a bigger country like Italy or Spain "might well mean game over for the Eurozone" (Tooze, 2018: 385). Italy, in particular, is sometimes considered the "first line of defense" against a broader Eurozone crisis, which has the second highest debt-to-GDP ratio (133%) behind Greece (Reid et al, 2018: 42). Deutsche Bank economists ask: "what happens when the ECB slows down the rate of [bond] purchases, bond markets start to reverse, and the cost of financing this debt load rises (ibid)?"

Chinese ownership of the bulk of US treasury securities – was thought by many in the early 2000s to be the most dangerous source of looming economic crisis (Tooze, 2018: 35). For example, the Congressional Budget Office in 2003 noted the potential for an "extreme scenario in which foreign investors stopped buying US securities, the dollar plunged and interest rates and inflation shot up" (ibid: 30). However, rather than eroding dollar hegemony, the 2007-08 GFC and subsequent response reinforced perceptions of the US dollar as the world economy's most liquid asset in times of crisis, therefore strengthening the role of the dollar as the world's reserve currency (ibid: 214). But how sustainable is this position? At what threshold would China and other investors perceive that the economic costs of a mass sell-off of US securities, and resulting devaluation of their dollar-based assets, were lower than the benefits? Barry Eichengreen notes that geopolitical dynamics are unlikely to provoke a run on the dollar on their own; rather, he argues that the primary danger is a collapse of confidence resulting from "budget deficits out of control" (Eichengreen, 2014). In this scenario, escalating deficits would reach a threshold beyond which investors would scramble to get out; the Fed would likely step in by buying bonds to counter interest rate spikes, but this would merely incur additional debt, becoming a "process without end" (ibid). Thus "at some point…investors will recognize this behavior for the Ponzi scheme that it is", and this scenario could "develop not gradually, but abruptly. Previously sanguine investors will wake up one morning and conclude that the situation is beyond salvation.…The United States will suffer the kind of crisis Europe experienced in 2010, but magnified" (ibid). Eichengreen is optimistic that this scenario will be avoided, and he claims that "serious economic and financial mismanagement by the United States is the only thing that could precipitate flight from the dollar" (ibid). Of course, this is precisely what we've seen under the Trump administration, which has increased the deficit 68% between 2016 and 2019 (from $585 billion to an estimated $984 in 2019) (Croucher, 2019). With the world economy at high risk of entering a recession in the next few years, and crisis management capacities potentially stretched to their limits, it is clear that a collapse of confidence in the US dollar remains a possibility, and its resilience will likely be tested during the next crisis.

Others point to China as an accumulating source of systemic risk for global capitalism (Bello, 2019; Reid et al, 2018; Foster & McChesney, 2013). Credit growth in China has far outstripped the pace of GDP growth since 2012, leading to a whopping debt-to-GDP ratio of 303% in 2019 (Bloomberg News, 2019). Related to this has been the massive growth in China's shadow banking sector during the same period, including a "rapid build-up of wealth-management products, which draw parallels with western banks' exposures in the subprime crisis of ten years ago" (Reid et al, 2018: 45). It remains to be seen how these tensions will be resolved, but what "cannot be avoided" is that credit-fueled demand will decline, which would likely trigger recessions in China and the global economy at large (Keen, 2016: 102). Combined with the impacts of the ongoing US-China trade war, growing worker militancy (seen in over 100,000 protests per year), weakening economic growth, and a social contract that relies on persistently extraordinary growth rates to maintain political-economic stability, a case can be made that China in the near-term constitutes "the single weakest link for the global capitalist chain" (Foster & McChesney, 2013: 158).

Financial shocks originating in other sub-systems might include massive (possibly simultaneous) superstorms that devalue coastal real estate and trigger unpayable insurance claims, or multi-trillion dollar devaluations from stranded fossil fuel assets. Regarding the first, the Cambridge Centre for Risk Studies anticipates that superstorms in New York and Florida could each produce over $1 trillion in losses from infrastructure damages and their spill-over effects on real estate values, neighboring regions, and trading partners, which could generate further financial instability by triggering a higher-than-expected frequency of insurance claims and debt defaults among affected homeowners and businesses (Mahalingam et al, 2018). They note that these events would be unlikely to trigger a financial crisis and/or global recession on their own, though they also assume that markets would "react rationally and proportionately" (ibid: 8), which suggests that, especially in an environment of high debt and weak growth, more destabilizing dynamics should not be discounted. Additionally, rising temperatures will increase the probability of multiple extreme events occurring in a short time frame, as well as the probability that such events would coincide with ongoing recessions or financial crises, in which case "the consequences could be very much more severe" (ibid: 7-8).[147] Regarding the much discussed (yet poorly understood) "carbon bubble", Mercure and colleagues estimate that stranded fossil fuel assets lead to discounted global wealth of US $1-4 trillion, which would be comparable to the write-down suffered during the 2008 financial crisis (Mercure et al, 2018). However, these only account for write-downs in the energy sector; when taking into account second order impacts across the global economy, such devaluations may place up to $20 trillion at risk (NGFS, 2019: 17).[148] Jeremy Rifkin

[147] Some analysts believe that a chain reaction could occur if multiple extreme weather events generate higher than expected insurance claims and defaults for affected homeowners and businesses, thereby triggering significant losses among insurance companies and banks that would risk cascading into further losses through chains of counter-party claims (Dembicki, 2019). The growing market for "Catastrophe Bonds" increases the risk, since it may incentivize insurance firms to insure high-risk properties (mirroring the "originate to distribute" model in mortgage lending), and it expands the chain of counter-party claims by reeling in investors who may be unaware of the risks (ibid). This may be unlikely to create a financial crisis on the scale of 2007-08, since the market for catastrophe bonds is orders of magnitude smaller than the market for mortgage backed securities (an estimated $29 billion in cat bonds compared to $7.3 trillion in MBSs in 2007) (Mcgillivray, 2019). However, given the political-economic context of accumulating financial risk – seen in the combination of high debt, precarious growth, and risky lending (IMF, 2019) – combined with the possibility of significant under-estimation of climate risks by banks and insurers (Dembicki, 2019), we should not discount the possibility. Perhaps more importantly, rising temperatures will increase the likelihood that localized shocks to the financial system from extreme weather events would coincide with other crises – whether crop failures, supply-chain disruptions, or extreme weather in other regions – or that such events would happen in near-succession, thereby shocking economic-financial systems that are already in a weakened state.

[148] A report from the Bank of International Settlements shows how stranding an asset in one specific sector can trigger a "cascade of stranded assets" affecting many other parts of the global economy (Bolton et al, 2020: 39). For example, as they explain: "the mining and quarrying sector (including the extraction of fossil fuels), although it accounts for a relatively low share of value added, tends to provide crucial inputs for many other downstream economic activities such as construction, electricity and gas, coke and refined petroleum products or land transport; in turn, these sectors are critical for the correct functioning of public administration, machinery and equipment and real estate activities; and so on" (ibid). Thus they claim that "more work is still needed on how a climate-related asset price shock (eg stranded

may therefore be correct (if a bit sensationalist) in arguing that the carbon bubble alone could collapse the global economy between 2023 and 2028, though this scenario relies on the (likely unrealistic) scenario of a primarily market-driven accelerated transition to renewable energy in the next 5-10 years (Rifkin, 2019).

A financial crisis may likewise generate further shocks in energy and food systems, while also having uncertain consequences for climate change. First, as noted previously, a liquidity crisis could have dramatic consequences for the oil industry – especially unconventional oil production – by constricting flows of credit needed to finance exploration and infrastructure development. In conjunction with weakened demand depressing oil prices, therefore making unconventional projects uneconomical, this could accelerate the collapse of the fossil fuel industry (Ahmed, 2017). In turn, this could have beneficial implications for climate change both by slowing emissions and creating a window of opportunity for transitioning to a global "Green New Deal", but it may also incentivize states (depending on the regimes in power) to ramp up "growth at all costs" and perhaps even use state financing (e.g. in the case of the US) to rescue an ailing fossil fuel industry (ibid). As in 2007-08, a financial crisis may also contribute to food price spikes by fueling a wave of land grabbing and speculation on food futures, since they are "safe assets" in times of crisis (GRAIN, 2010; Homer-Dixon et al, 2015). A repeat of such dynamics may help catalyze a wave of collective anger and mobilization capable of ending neoliberal hegemony; but if such dynamics go unchecked by resistance, they would reinforce a collapse trajectory by further concentrating control of

assets) could trigger other losses within a dynamic financial network, including contagion effects towards non-climate-related sectors" (ibid: 42).

the food system and locking it into industrialized polluting/emitting/soil degrading practices (Clapp & Isakson, 2018).

Food Shocks

According to current modeling studies, major climate change-induced food system shocks are unlikely to occur between 2020 and 2030, though many agricultural models project that yields may begin to go negative in the 2030s (Challinor et al, 2014).[149] While these models assume no adaptation or technological innovation to enhance productivity, they are also unable to capture the full array of climate impacts on agriculture (e.g. extreme weather, pests, seasonal volatility), and thus the possibility of major global food system shocks before 2030 should not be discounted. The global food crisis of 2008, which was an important factor behind the wave of political upheaval known as the Arab Spring, shows that we need not wait to encounter such shocks (Ahmed, 2019a). It appears that the 2008 spikes were primarily the product of financial speculation and ramped up biofuel production (Lagi et al, 2012), which means that these same dynamics may generate further shocks in the coming years that would be made worse by intensifying climate impacts. Drought conditions are already fueling crop failure throughout Central America, East Africa, and Afghanistan, while heatwaves in 2018 bankrupted farmers across Northern and Central Europe (leading to state of emergency declarations in Latvia and Lithuania) (Neslen, 2018). In the United States, soybean and corn harvests for 2019 are expected to fall at least 8% below last year's

[149] One Integrated Assessment Model developed at Anglia Ruskin University even projects that, under a business-as-usual trajectory, a "collapse" of the global food system will occur by 2040, leading to "catastrophic losses, and an unprecedented epidemic of food riots". This result is based on the unrealistic assumption that there will be no significant technological or policy changes, but it at least demonstrates the potential for dramatic food crises in the not-too-distant future given current trends (see Dore, 2015).

levels, leading to a 1.4% rise in the UN Food and Agricultural Organization's cereal price index (Starr, 2019). Even in Sweden, where yield increases from rising temperatures are supposed to offset losses elsewhere, yields hit their lowest levels since 1993 in 2018 (Neslen, 2018). With intensified flooding, heatwaves, hurricanes, and water stress – projected to impact half of the global population by 2025 (WHO, 2019) – posing increasing risks to food supply in the near term, we should not be surprised if the 2020s already witness major food shocks with cascading consequences for the neoliberal world order. And as we saw in 2008, financial speculation may turn a modest price increase into a dramatic spike (Bar-Yam et al, 2012), which means that even relatively moderate climate impacts may generate food crises that are disproportionate to the initial stimulus.

While near-term food system shocks would likely be comparable to the 2008 and 2011 food crises that generated food riots across the world-system, we should also take seriously the risk of more extreme scenarios. Jonathan Porritt, for example, in his "history of the future" envisions a global famine killing 10 million people in 2025 – triggered mainly by a new variety of black stem rust (a fungal pathogen) wiping out harvests across Africa, the Middle East, and East Asia – which then becomes the "definitive turning point" for transitioning beyond neoliberal capitalism (Porritt, 2013: 96). While perhaps extreme, a collaboration between food security experts and Lloyd's Insurance develops a comparable (albeit explicitly worst-case) scenario playing out sometime in the near future. In this scenario, a strong warm-phase of the El Nino Southern Oscillation generates simultaneous weather extremes and major breadbasket losses from North America to India and Russia, while a rust stem pathogen simultaneously wipes out harvests across Asia and South America. As the report describes:

> The combined effects of these shocks result in global crop production declines of 10% for maize, 11% for soybean, 7% for wheat and 7% for rice…wheat, maize and soybean prices increase to quadruple the levels seen around 2000. Rice prices increase 500% as India starts to try to buy from smaller exporters following restrictions imposed by Thailand…Food riots break out in urban areas across the Middle East, North Africa and Latin America…India and China start to become more forceful in seeking contracts for food imports to be fulfilled…Russia continues to intervene in Ukraine and expresses concern that other eastern European countries may become unstable following food riots…The euro weakens and the main European stock markets lose 10% of their value amid the possibility of military action, increasing pressure on southern European borders owing to immigration from North Africa, an unstable eastern Europe and further sanctions against Russia. US stock markets follow and lose 5% of their value (Maynard, 2015: 10, 15).

While this is a worst-case near-term scenario, it dramatizes the potential for cascading geopolitical and economic consequences that could upend world order in the case of a major food crisis.

Overall, food system shocks may remain primarily localized and have limited global systemic consequences in the next decade (though the Covid-19 pandemic may be setting the stage for a big one, which remains to be seen) (Cribb, 2020). But we should not lose sight of the fact that food crisis and starvation are already impacting populations across the global south as a result of "complex emergencies" emerging from extreme weather, global market liberalization, internal conflict, and drought (Keen, 2008), with more than 52 million people threatened with hunger in Africa alone in 2019 (Oxfam, 2019). Thus from the perspective of these populations – not to mention under-privileged populations in the global north (including an estimated 40 million food insecure people in the US, most of them African American) – we don't need to wait 10-20 or more years for a major food crisis (Coleman-Jensen et al, 2018). Hence the importance of investigating these crises from multiple individuating perspectives across geographical and intersectional differences, something I can barely do justice to. But it is also important to consider the potential for food shocks capable of triggering a global systemic crisis (i.e. more than a continuation of the "normal" deprivation that marks global capitalism's daily operation).

The SEP Solution-Space

Overall, it appears that the resilience of the capitalist world-assemblage is eroded from within and without by the convergence of political-economic, financial, climate, energy, food, and psycho-social stressors; if we could perceive its virtual phase space, we would see a shrinking attractor basin and the appearance of multiple alternative attractors separated by a catastrophe fold. It therefore appears that global capitalism may be losing its "adaptive capacity" (Scheffer, 2009), or its capacity to "restructure itself out of great crises" (Moore, 2015). Following Jason Moore, if the problem capitalism confronts is one of reinventing "cheap nature" in an eco-geographical context where the sources are depleting, the sinks are filling, and the scope for expansion is increasingly circumscribed, it becomes difficult to imagine how it could double (let alone triple) its size in the coming decades while stabilizing the earth system, as optimists confidently expect (Moore, 2015a). In addition to facing the problem of how to perpetuate 2-3% annual compound growth by finding $2 trillion worth of profitable investment for surplus capital rather than relying on speculation and credit fuelled boom and bust cycles (Harvey, 2014), capitalists must accomplish this while managing the rising costs of climate impacts, "internalizing" the costs of environmental pollution (especially but not only carbon), navigating beyond net energy decline towards a new cheap energy regime, reinventing cheap food, and forming a new "class compromise" to secure capitalist legitimacy among increasingly restless populations. In short, while each of these problems are difficult in their own right, the capitalist world-assemblage must resolve them all simultaneously.

The "neoliberal" configuration of the capitalist world-assemblage – defined by the dominance of global finance capital, structural incentives towards short-term profitability, and a primarily "free market" approach to the sustainability transition – is in particularly deep trouble, since it is incapable of escaping the cycle of debt-dependent growth followed by financial collapse, let alone mobilizing the financial resources needed to accelerate the energy transition in time to avoid the twin dangers of fossil fuel depletion and runaway climate change (UNCTAD, 2019). In short, it is destined for terminal crisis[150] – whether in the form of near-term transition to Green Neo-Keynesianism, near-term collapse, or a spatiotemporally uneven long-term collapse. But while the attractor space/adaptive capacity of global capitalism is shrinking on the whole, it has not yet been exhausted (though it may well fail to actualize).

While this is not necessarily the most probable outcome, I believe there is *one* attractor into which global capitalism can transition while retaining its core structure, functions and feedbacks (at least for a time), which would be the "Green Neo-Keynesian" solution. Before describing the likely contours of a Green Neo-Keynesian solution, however, it is important to briefly recall some of the main obstacles it confronts, especially given the bulk of evidence weighing against the possibility of rapidly decoupling economic growth from emissions and other environmental impacts. Most importantly, as discussed in chapter one, while the IPCC claims emissions need to reduce

[150] This is not to say that any future climate-financial-energy-food crisis will *inevitably* lead to a transition beyond neoliberalism, or to its *immediate* collapse. Rather, if concentrated oligarchic control of the global economy prevents significant reform despite future rounds of convergent crises, then these shocks will only intensify over time while ownership of increasingly scarce assets (e.g. land and water) becomes more and more concentrated, leading to either near or long-term collapse.

7% annually to reach net zero emissions by 2050 to meet the 1.5°C target (and possibly even the 2°C target) (Rockström et al, 2017), modeling evidence suggests that the global capitalism could at most decarbonize 3-4% per year in a context of compound growth (Hickel, 2019: 55), and would need to begin more-or-less *immediately*. On top of this, economic growth must also be *absolutely* decoupled from impacts on other planetary boundaries that may have already been overshot, which include land use change, biodiversity loss, and nitrogen/phosphorous loading (Raworth, 2017), which will require a rapid transition to a sustainable low-carbon and low-meat food system (Willett et al, 2019; Springmann et al, 2019).[151] However, it is also practically certain that any ambitious near-term climate mitigation program (i.e. beginning within the next 5-10 years) will need to operate under capitalist constraints. On one hand, it is possible that such an ambitious mitigation program simply won't materialize, in which case either energy-financial-food shocks or runaway climate change and ecological collapse will drive world-assemblage collapse in the coming decades. On the other hand, an ambitious globally coordinated climate emergency mobilization (Delina, 2016), involving a radical

[151] Walter Willett, Johan Rockström, and other scientists argue that this will require 1) decarbonizing the food value change – from production to consumption – by 2050; 2) keeping emissions from agriculture at less than 5 gigatons of CO2 equivalent by 2050 and eventually becoming a carbon sink (taking out 10 gigatons per year) by 2100; 3) ending or at least dramatically reducing use of synthetic fertilizers and insecticides due to their detrimental impacts on biodiversity; 4) feeding humanity on existing agriculture while adopting a "Half Earth strategy" for biodiversity conservation by protecting 50% of Earth as intact ecosystems; 5) reducing food loss and waste by 50% to reduce pressure on food demand; 6) transitioning to "sustainable intensification" of food production while adopting sustainable practices for soil, water, nutrients and chemicals; and 7) reductions in meat consumption of 80-90% (from an estimated 2000 to 300 grams per week) (Willett et al, 2019; Springmann et al, 2019).

Can all this be accomplished within a global capitalist framework in which, as Jennifer Clapp & Ryan Isakson show, "agribusinesses have embraced a growing belief that their primary function is to provide profit for shareholders, rather than to serve society's wider interest to provide nutritious food that is universally accessible as well as decent livelihoods" (Clapp & Isakson, 2018: 14)? The called for reductions in meat consumption could potentially be made possible by advanced in plant-based alternatives and lab-grown meat. But the shift to a sustainable food system will require what Rockström and colleagues call a "Great Food Transformation…a substantial change in the structure and function of the global food system so that it operates with different core processes and feedbacks" (Willett et al, 2019: 31). This will not be possible under the current neoliberal food regime that prioritizes shareholder value. On the other hand, a Green Neo-Keynesian regime that significantly de-financializes and re-structures the food system to support small-to-medium size farms and sustainable practices might be able to accomplish many aspects of the transition. However, the feasibility of a "Half earth strategy" in the context of a continuously growing capitalist economy appears dubious (short of radical technological advances).

reform of the global economy away from neoliberal dictates, could emerge in the next 5-10 years that begins reducing emissions at around 3-4% per year – not fast enough to meet the 1.5°C target, *possibly* fast enough to meet the 2°C target (at least in conjunction with scaled up net emissions technologies), but certainly a significant step in the right direction.

Thankfully, efforts to initiate such policies in core nation-states are beginning to gain steam, seen in the growing discourse of the "Green New Deal" (GND). While largely a nebulous and aspirational program at present, with multiple competing visions and policy proposals, the GND can broadly be understood as a project to re-align global capitalism with Green Neo-Keynesian principles by enacting state-led investment in renewable energy and clean technologies, creating massive "green jobs" programs, converting the industrial food system to organic and "climate smart" agriculture, strengthening financial regulation and converting "too-big-to-fail" banks into public utilities, and creating new global architecture for trade and finance that enhances national autonomy over economic policy and development priorities (UNCTAD, 2019; Commonwealth, 2019; Aronoff et al, 2019; Pettifor, 2019). With GNDs being developed and supported by left-wing (and even some center-left) parties in the US and Europe, it appears to signify a viable alternative attractor at both national and world-assemblage scales that would at least begin seriously addressing the converging crises of the SEP.

But could a global GND, even if it materializes, form the basis of a sustainable "long wave" of capital accumulation that stabilizes the climate while managing other earth system impacts in a context of compound growth (Chase-Dunn & Lawrence, 2011)? I will suggest that *yes*, this is at least possible in principle, though it would require something like a "Fourth Industrial Revolution" (FIR) driven by mutually reinforcing breakthroughs in nanotechnology, biotechnology, artificial intelligence, 3d printing, the internet of things, and other developments (Schwab, 2017), which would be capable of simultaneously increasing labor productivity, restoring the profitability of manufacturing vis-à-vis finance, raising the EROI of renewable energy and storage systems, and accelerating the rise and dominance of low-carbon industries. After all, the best (arguably only) hope for rapidly decoupling economic growth from growing resource use and environmental impacts would be a technological revolution that renders current modeling projections of material-energy efficiency improvement rates obsolete. Indeed, Kallis and Hickel acknowledge that "[w]e cannot rule out substitutions or technological breakthroughs that will push such limits so far into the future as to render them irrelevant" (Kallis & Hickel, 2019: 13).[152] In Jason Moore's related conceptualization, such breakthroughs could defy current predictions of peak energy and peak food by unlocking vast new reserves of "cheap nature" that can fuel a new cycle of capitalist expansion (Moore, 2015).

Green Neo-Keynesianism

In this scenario (emerging sometime between 2020-2035), FIR technologies stimulate breakthroughs in solar energy (including battery systems, smart grids, and nano-PV panels), biofuels, agriculture, net emissions technologies (NETs), transportation, and supply-chain logistics that enable an absolute decoupling between economic growth and GHG emissions (though *not* overall material-energetic

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[152] Following Mauro Bonauiti, this would entail a novel assemblage of "Promethean Technologies" capable of generating positive feedback that enables them to produce a surplus of available energy and productivity that vastly exceeds the costs that go into their production (Bonaiuti, 2018).

throughput).[153] Emissions fall 3-4% annually to reach net zero by 2070, thereby overshooting the IPCC targets to stabilize temperatures at 1.5°C, though technological breakthroughs enable a rapid and massive upscaling of NETs to pull 5 gigatons of carbon annually out of the atmosphere by 2050 (as the IPCC's "overshoot" scenarios call for), thereby stabilizing average global temperature around 2°C (IPCC, 2018). This level of warming continues to intensify drought, wildfires, floods, and extreme weather around the planet, though technological advances enable resilient crop varieties that can withstand many of these changes, vertical farms and lab-grown meat that can feed growing populations with reduced emissions and soil impact, scaled up desalination to attenuate water shortages, and widespread 3d printing to make local infrastructures more adaptable and easier to rebuild in the wake of disasters. A Green Neo-Keynesian hegemony displaces neoliberalism as a critical mass of global elites recognize and act on the need to shrink and intensify regulation over the financial sector, enact significant redistribution efforts through progressive tax reforms and debt cancellation, fund the $100 billion per year in adaptation funds promised to the global south,[154] and (over time) provide universal guaranteed income for populations to ensure access to basic needs and stymie the social unrest that would undoubtedly result as FIR advances automate greater swathes of the global economy. Patterns of uneven development and exploitation persist throughout the world-system (especially given the reliance of renewable-powered

[153] See Jonathon Porritt's *The World We Made*, a fictional history of the first half of the 21st century written by an observer in 2050, for an impressively detailed account of what a such a world might look like (though it excludes nuclear power, believing renewables will meet all energy needs) (Porritt, 2013). Its primary flaw is that it does not adequately clarify the structural changes to the global political-economy that be necessary to realize its vision and how these would be brought about; in particular, it does not state whether or not economic growth will be continuously sustained at a compound rate, and if not, then whether the resulting steady-state economy could reasonably be called "capitalist". But it remains a useful and thought-provoking resource for considering future possibilities nonetheless (from a refreshingly optimistic, and not entirely implausible, perspective).

[154] However, the UNEP estimates that the true cost of adapting to climate change for southern states is more likely to range between $140 and $300 billion per year by 2030 (Zorba, 2016). like Manuel Montes believe the total needs may be even higher – in the range of $600 to $1500 billion per year (Raman, 2012).

infrastructures in the global north on strip mining in the global south), billions remain in poverty and dangerously exposed to the impacts of a 2°C average global warming, and many states – especially in North Africa and the Middle East – teeter on the brink of or plunge into chaos. Yet the shift from a neoliberal to a Green Neo-Keynesian global attractor enables more states throughout the global south to fund public welfare programs and autonomously determine their development priorities. Many environmentalists warn that material-energetic throughput continues to steadily rise even as the global economy grows at a slower pace, which continues to erode biodiversity while putting stress on the capacities of forests, soils, and other ecosystems to sequester carbon, again threatening to trigger feedback mechanisms that would destabilize the climate. Yet it is generally believed that the success of renewable energy (in conjunction with a modestly scaled up nuclear fleet) has at least bought the world-system more time to deal with these challenges, while continuing advances in nanotechnology, biotechnology, and AI make many confident that the capabilities to solve any problem that emerges in the earth system are now within humanity's grasp.

I am not very confident concerning the realism of this scenario, though it appears to at least be a plausible future state of the world-assemblage *if* 1) movements for labor and environmental justice succeed in pressuring governments in the hegemonic nodes of the world-assemblage – especially the U.S., Europe, and China – to make substantial concessions to popular demands for accelerated climate mitigation and redistribution in the next 10-15 years, and 2) FIR breakthroughs succeed in laying the material-energetic foundations for a sustainable long wave of "green growth". However, the longer governments wait to institute a global GND as an effort to simultaneously resolve the crises of capitalism, climate change, food and energy, the less likely it will be to succeed, and the more likely a radically discontinuous trajectory (whether in the form of "revolution" or "collapse") becomes.

The (Likely) Crisis of Green Neo-Keynesianism

As discussed above, there is good reason to believe that a Green Neo-Keynesian solution would not be sustainable, primarily on material-energetic and ecological but also political-economic grounds (barring unprecedented technological breakthroughs). We should therefore ask: even if core states *do* shift to something like a GND in the coming years, would it be able to generate sustainable and inclusive growth like its advocates claim? Or would it more likely bring about persistent stagnation, political-economic turbulence, and continued ecological degradation? While we cannot know for certain, it is important to explore the later possibility, since this would be the context in which a GND could lay the preconditions for either a more radical post-capitalist transition (i.e. ecosocialism) or global collapse.

There are at least four reasons why the latter scenario may be more likely. First, is the problem of net energy decline: as we shift to renewable energy sources with a lower EROI, less energy may be available for the global economy overall, thus constraining its capacities to expand (barring rapid FIR breakthroughs, in which case see MMVP section below) (Capellan-Perez et al, 2019; Heinberg & Fridley, 2016; Kallis, 2018). Second is the possibility of "green jobs" promises being oversold, which would likely be the case after an initial 10 year burst of government-led job creation; once the solar and wind farms are installed, houses are retrofitted, and new public transit systems are in place, will there be sufficient opportunities for paid employment?[155] Furthermore, optimistic assessments of "green job" creation often focus primarily on net gains within the energy sector (e.g. Klein, 2019: 281), which may downplay the massive disruptions that would be triggered by decarbonizing the rest of the economy – from manufacturing and petrochemicals to aviation and shipping (Smith, 2016: 112). Third, there is also the risk that increased deficit spending needed to finance a GND will increase (already precarious) government debt levels to *even more* precarious heights (Bovari et al, 2018). While most Neo-Keynesian analysts assume that increased government spending would have a positive impact on economic growth, thereby making the increased debt sustainable (Klein, 2019: UNCTAD, 2019), this assumption may be based on unrealistic expectations about the GND's capacity to boost system-wide labor productivity, particularly given the challenges of reviving "cheap energy" and "cheap food" in an era of climate turbulence and declining EROI (again, assuming the FIR doesn't come to the rescue) (Moore, 2015; see also Bolton et al, 2020: 58).[156]

Finally, the "transition risks" posed to carbon-intensive assets and financial stability will likely provoke a crisis if we reduce emissions at anywhere near the rate demanded by the Paris Agreement targets. As a recent report from the Bank of

[155] Aronoff et al recognize this problem: "building solar panels and wind turbines is a transitional strategy – not a model for a new economy. We can't just ramp up the production of 'green' technology indefinitely. We need a plan for what comes next" (Aronoff et al, 2019: 79). This will create an opportunity for a more radical ecosocialist transition as the GND fizzles out, but it would obviously require intense counter-hegemonic struggle to push the crisis towards a steady-state ecosocialist transition.

[156] On the question of whether states can afford a fiscal expansion, a 2019 UNCTAD report writes: "What matters most is the flow of revenue that accrues to the government over a period of time as a result of tax and expenditure changes and their subsequent impact on GDP through the fiscal multipliers…If production cannot be expanded despite the presence of unemployment, typically because of bottlenecks in other factors or financing…there will be associated limits to the impact of fiscal policy on aggregate demand. Therefore, expansionary fiscal policy requires a careful approach" (UNCTAD, 2019: 48). In this sense, the current situation of high public debt does not mean a fiscal expansion would be undesirable (as deficit hawks claim). However, if renewable energy constraints and the need to "internalize" ecological costs create a "bottleneck" on efforts to increase productivity, then state expenditures may not be met by a corresponding increase of aggregate demand, economic growth, and tax revenues. In this case, the "fiscal multipler" would fail to materialize, and a "stagflation" crisis may result.

International Settlements (BIS) states: “extremely rapid and ambitious measures may be the most desirable from the point of view of climate mitigation, but not necessarily from the perspective of financial stability over a short-term horizon” (Bolton et al, 2020: 7). Thus, given the slow progress so far on carbon pricing and emissions cuts, it is likely that efforts to rapidly decarbonize will catalyze a “climate Minsky moment”, thereby destabilizing the global economy and requiring even more government intervention (and likely nationalization) to transition carbon-intensive industries to low-carbon forms and protect displaced workers. On the other hand, if a GND does not rapidly reduce emissions, e.g. only doing so at 2-3% annually, a carbon bubble crisis may be avoided but the risks of climate-financial-food-energy shocks will increase. As the BIS report explains:

> A strong and immediate action to mitigate climate change would increase transition risks and limit physical risks, but those would remain existent…In contrast, delayed and weak action to mitigate climate change would lead to higher and potentially catastrophic physical risks, without necessarily entirely eliminating transition risks…Delayed actions followed by strong actions in an attempt to catch up would probably lead to high both physical and transition risks (ibid: 18-19).

Therefore, a GND may be stuck between a rock and a hard place: intense transition risks from stranded assets if emission reductions accelerate, or intense physical risks if emissions reductions are too slow. And if an ambitious GND-style mitigation program is delayed until 2030 or beyond (which seems likely) then it would likely be destabilized by a combination of *both* stranded assets and climate-energy-food shocks.

In this way, short of an FIR-driven technological revolution to enable a long wave of green growth, a global GND may turn out to be a temporary way-station located on an unstable catastrophe fold between two more radically discontinuous world-assemblage trajectories: either towards greater nationalization, planning, and rationing on one hand to rapidly reduce emissions while ensuring basic needs are met; or a rightwing reversion to "growth at all costs" taking us down the road of global collapse. In a context of persistent low growth, worsening climate impacts, and evidence that even a global GND is unable to reduce emissions with the necessary speed, a strong enough network of labor and environmental movements across the globe – likely requiring far more than the 3.5% of the population proposed by Chenoweth – *might* succeed in pushing governments to radicalize the GND in the direction of planning, a reduction in the work week, contraction of wasteful consumerism (especially in the global north), and radical redistribution as a substitute for economic growth (Hickel, 2019). In this way, as William Robinson contends, the emergence of more radical alternatives may "snowball out of efforts to bring about a reform of the [global capitalist] system" (Robinson, 2014: 233). Thus while they appear utopian in the present political-economic context, as Nafeez Ahmed contends: "By 2030, and even more so by 2050—as the manifestations of global capitalism's self-catabolic trajectory become more obvious—[they] will appear increasingly realistic" (Ahmed, 2017: 91). We should therefore not ignore the possibility that a combination of political-economic, ecological, and psychosocial tipping points in the next decade or two will enhance the plausibility of progressive post-capitalist solutions for core nation-states and the capitalist world-assemblage as a whole. In particular, as Ecological Marxists and various "degrowth" scholars argue, a low-throughput "ecosocialism" would be the ideal resolution of the SEP, one that doesn't shift problems onto other domains or vulnerable populations and that could meet the needs of all humans while stabilizing the earth system.

Ecosocialism

There is no single agreed upon definition of ecosocialism, which would itself take a multiplicity of forms in specific local and regional contexts (just as capitalism does). Yet we can broadly define an ecosocialist world-assemblage as one in which the power of capitalists to organize collective labor and production for the ends of private profit would be subordinated to public and social economies[157] based on coordinated central and local planning, communal control of local socioecological commons, and greater participation by workers and consumers over what gets produced and how (R. Smith, 2016; Angus, 2016; Baer, 2018; Bellamy Foster et al, 2011; Sarkar, 2012). As Hans Baer imagines, it would entail a predominant public sector combined with large cooperative and private sectors consisting primarily of small and medium companies that provide various goods and services, which would be primarily configured to meet the basic needs of all humans in metastable equilibrium with local ecologies and the earth system as a whole (Baer, 2018). This would require transitioning to a "steady-state economy" in which material-energetic throughput remains constant, though this would need to be preceded by "managed degrowth" or selective deindustrialization in the global north in order to secure a fair share of energy and raw materials for populations in the global south who still lack access to sufficient electricity, clean water, sanitation, and health care (R. Smith, 2016: 114). Transformation of the global food system would be critical in such a scenario,

[157] As Conaty and Lewis explain, the public economy refers to the sector of the economy concerned with the planned provision and distribution of public goods and services, while the social economy refers to various local and cooperative modes of exchange based on reciprocity rather than monetary transactions (Conaty & Lewis, 2012: 29). In this sense, whereas the private market economy – sector based on production of goods and services for private profit – is dominant within a capitalist system, an eco-socialist system would entail the subordination of the private market economy to the public and social economies, rather than its outright abolition (though this could constitute a longer-term evolutionary objective).

which would require relocalizing food production as much as possible through agroecological and polycultural methods that sequester carbon, conserve water, and strengthen the soil, involving global scale land-reforms based on principles of "food sovereignty" that return stewardship rights to indigenous peoples who have been displaced by the neoliberal agro-economic transition (many would say "catastrophe") of recent decades (McMichael, 2013).[158] Overall, an ecosocialist world-assemblage would ideally involve a balance between local autonomy and global coordination, where emergent modes of collective individuation throughout the world-assemblage establish democratic control of their local commons, though their socioecological metabolisms would be constrained within the parameters set by national, regional, and global plans to limit material-energetic throughput to levels compatible with earth system regeneration and redistribute resources to populations who are least responsible for and most vulnerable to climate change.

An ecosocialist world-assemblage, one that results in a steady-state economy with lower levels of material-energy consumption than at present, would be most capable of solving the SEP with minimal problem-shifting primarily because it would not be reliant on continuous compound growth, and because it would no longer be necessary to prioritize solutions that further the ends of capital accumulation. Redistribution of material-energy and financial resources, both within and between states, would replace endless growth as the primary strategy for poverty alleviation (Hickel, 2019), and endless

[158] There are of course concerns over whether such methods would be adequate to feed a growing population. While a plethora of research suggests it would be possible (and is simply necessary, due to looming energy, soil, and other earth system constraints) (Jeavons, 2001; Rodale Institute, 2012), this would likely require a more radical global political-economic transformation in which the wasteful sectors of the economy are shrunk while agricultural labor and activities take up a greater proportion (Smith, 2016). It may also be necessary to use next generation industrial production techniques like "plantscrapers" and "Zero-Acreage Farming" practices to more sustainably feed cities, while biotechnological manipulation can potentially play a positive role if freed from its current draconian intellectual property regime and integrated as part of a global commons (Biel, 2014).

growth would no longer need to be absolutely decoupled from resource use via speculative technological breakthroughs (which would themselves create new catastrophic risks). Food production would no longer need to be shifted into biofuels or continue to rely on global supply chains, off-farm inputs, and wasteful forms of packaging and retail, but could instead be reorganized locally in a way that would generate added climate benefits by sequestering carbon and improving biodiversity. Energy constraints imposed by falling oil production and the limited EROI of renewables would no longer be a problem, since new modes of collective individuation would emerge based on more frugal and community-oriented visions of the good life. This analysis concurs with the IPCC's 2018 report, which concludes:

> 1.5°C pathways that include low energy demand…low material consumption, and low GHG-intensive food consumption have the most pronounced synergies and the lowest number of trade-offs with respect to sustainable development and the [Sustainable Development Goals] (*high confidence*) (IPCC, 2018: 26).

The IPCC does not explicitly call for degrowth (though they come close in some parts),[159] let alone ecosocialism. Yet when we account for the evidence against the compatibility of perpetual compound economic growth and earth system stabilization, as well as the severe structural crisis that global capitalism confronts and the constraints this imposes on SEP solutions, the need for an overall global reduction and redistribution of material-energy resources becomes evident, which could only be accomplished equitably under some form of global ecosocialism.[160]

[159] For example: "The profound transformations that would be needed to integrate sustainable development and 1.5°C-compatible pathways call for examining the values, ethics, attitudes and behaviours that underpin societies...values that promote sustainable development...*overcome individual economic interests and go beyond economic growth*...encourage desirable and transformative visions...and care for the less fortunate...are part and parcel of climate-resilient and sustainable development pathways"(IPCC, 2018: 475; italics added).

[160] This conclusion raises the question of the threshold between "capitalism" and "socialism". For the most part I follow Marxists in assuming that growth is a built-in feature of capitalism, and that the latter cannot survive without the former. Thus any post-growth or steady-state economy would of necessity need to be post-capitalist. However, it is possible *something like* "capitalism" would be compatible with zero-growth, which might be designed through a

However, this is admittedly an ideal and unlikely scenario, and one must not underestimate the cognitive-affective transformations it would require and the resistance it would need to overcome and continuously hold at bay until its attractor basin is sufficiently "deep" (i.e. until its cognitive-affective, socio-ecological, and security assemblages are sufficiently established and mutually reinforcing so as to deepen its resilience). As Quincy Saul counsels, the persistence of capitalist values in more socialist nation-states like Venezuela and Cuba, and the dogged efforts of elites to sabotage the revolutionary process, should be a warning for those hoping for a smooth ecosocialist transition in core states of the world-assemblage (Saul, 2011). Furthermore, as Stan Cox argues, ecosocialist degrowth and redistribution would not just require expropriation of the richest 1% or even 10%, but may require a steep decline in the purchasing power of the richest 33% in countries like the United States (Cox, 2020). Therefore, resistance from this sector of the population may be intense, and this doesn't begin to appreciate the depth of visceral resistance from political-economic elites and their multi-billion dollar dark money networks, middle class conservatives, and gun-wielding libertarians (especially, but not solely, in the US). Ecosocialists like Richard Smith, Ian Angus, and Michael Lowy believe that an ecosocialist transition could come about by democratically electing parties running on ecosocialist platforms (Smith, 2016; Angus, 2016; Lowy, 2015). Given the upheavals that even core countries will likely be experiencing in the coming decades, and the fact that significant percentages in core states are already

combination of new ownership structures that don't emphasize quarterly profits, a global cap on material-energetic throughput, and a Universal Basic Income or some form of employment guarantee to protect workers (Lawn, 2011; Daly, 1996; Jackson, 2011). It is at least a more plausible vision than the one of absolute decoupling of growth from environmental impact, though it would likely require such a degree of subordination of the private market economy to the "public" and "social" economies that it may be trivial to call it "capitalism", even if certain capitalist institutions like markets and private enterprise continue to exist (Conaty & Lewis, 2012).

expressing support for socialist policies,[161] we should not discount this possibility. Yet it is difficult to envision a large majority of populations in the global north – at least given their currently dominant cognitive-affective attractors – agreeing to significantly retrench their consumption without a combination of intense political-economic crisis and centralized emergency rationing, involving some form of authoritarian imposition on recalcitrant populations (Fischer, 2017). Quincy Saul and Andreas Malm are among the few ecosocialists who don't shy away from this problem. As Malm writes, it may require

> warlike state management of all industries, premature liquidation of astronomic amounts of capital sunk in fossil infrastructure, centralized decisions on who can consume what goods in what amounts, punishment of transgressors threatening the annual emissions targets…[which] can only be feasible under an exceptional regime dealing with an unheard-of emergency (Malm, 2015: 187).

In short, ecosocialists cannot dismiss the possibility that their calls for material-energetic degrowth, rationing, and redistribution would lead to (if not require) authoritarian imposition on consumerist populations, former elites, and other resistant forces (possibly armed[162]) in the global north.

Therefore, the hope for democratic forms of low-throughput ecosocialism may be contingent on the emergence of new modes of collective individuation from below based on new cognitive-affective patterns, values, and relations to the universe, though these will necessarily take distinct forms based on bioregional, historical, and cultural contexts. Fortunately, movements like Commoning, Solidarity Economies, Transition Towns, and other local economy and resilience-building initiatives provide hope that the seeds of new

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[161] Recent polls show that 40% of Americans (and 60% under the age of 30) claim to prefer socialism to capitalism (Younis 2019). And in the U.K., the Labour party under Corbyn adopted a radical Green New Deal proposal – which includes nationalizing the largest energy companies, expanding universal basic services, repealing anti-trade union laws, and transferring resources to the global south – thereby aligning the left-wing of the party with ecosocialist principles (Saltmarsh 2019).

[162] The present spectacle of armed militias joining anti-lockdown protests during the Covid-19 pandemic gives us a taste of what ecosocialists in the US are up against.

modes of collective individuation are indeed spreading throughout the planet (Henfrey & Kenrick, 2017; Birnbaum, 2014; Holmgren, 2002; Hopkins, 2008; Penha-lopes et al, 2019; Venn, 2018; Swilling, 2019; Colon et al, 2016; Fischer, 2017). As David Bollier and Silke Helfrich describe, these movements aim "to develop an independent, parallel social economy, outside of the market/ state system, that enacts a different logic and ethos" (Bollier & Helfrich, 2019: 4). In particular, they encompass diverse initiatives to relocalize and decarbonize food and energy assemblages to make them more resilient to the effects of climate change and energy depletion, while also democratizing ownership of common resources – from the land and water to knowledge and urban spaces. Commoning initiatives are spreading on multiple continents across the globe and are at the forefront of concretely posing and resolving the problems of inventing low-carbon economies and life-support assemblages – including food and water, energy, transportation, housing, and healthcare systems. At the same time, they are also explicitly responding to the Existential Problematic by addressing the communal deficit that is rampant across the global north, which could potentially help heal divisions between the urban/cosmopolitan left and rural conservatives by finding common ground in re-weaving "the social, cultural and economic webs of place-bound, interdependent community" (Quilley & Barry, 2009: 17).

However, these movements remain small and imperfect oases in the (still expanding) global desert of the "imperial mode of living" (Brand & Wissen, 2012). The question is whether intensifying climate-food-energy-economic crises could generate a rapid phase transition in cognitive-affective assemblages in core states, thereby making values like voluntary simplicity and more community-oriented and frugal visions of the good life seem like “common sense” (in the Gramscian sense). At the same time, it would require linkages to a strengthened and increasingly coherent labor and environmental movement able to coordinate general strikes across these countries, and perhaps transnationally (Aronoff et al, 2019), in order to push governments to adopt radical environmental policies while simultaneously fighting off the forces of reactionary backlash. In sum, those hoping for an ecosocialist degrowth transition cannot deny that, to paraphrase Nick Dyer-Witheford, it would need to cross a “river of fire” teeming with conflict and struggle that could last decades or longer (Dyer-Witheford, 2015).

Collapse

If a Global Green New Deal fails to materialize, doesn’t deliver on its promises, or emerges too late; or if more radical solutions don’t emerge and the solution-space remains dominated by a “rent-seeking financial-food-energy-biomass complex” that profits from ecological scarcity (McMichael, 2013: 121), then it is difficult to avoid the conclusion the capitalist world-assemblage will continue cascading on a trajectory towards “collapse”. Collapse here is understood in the sense defined in Joseph Tainter’s classic work as a “pronounced loss of an established level of sociopolitical complexity” resulting in reduced global integration, governance capacities, standards of living, and population levels (Tainter, 1988: 193). IPE scholar Tim Di Muzio, as well as Nafeez Ahmed, Thomas Homer-Dixon, Lester Brown, and many others come to similar conclusions, with Di Muzio arguing that world order is likely to undergo

> a multiscalar, multidimensional, and internationally interconnected series of events whereby current patterns of energy-intensive production, consumption, and reproduction can no longer be sustained, let alone expanded (Di Muzio, 2015: 153-154).

There are many ways such a collapse could play out, from a "long descent" punctuated by a series of unstable equilibriums that give way to lower-level equilibriums (Greer, 2008), or a more rapid process of cascading failure where mutually reinforcing energy and economic crises cripple critical infrastructures on a global scale (Homer-Dixon, 2006; Korowicz, 2011). The horror of such scenarios, especially the more rapid versions, cannot be understated, though it is crucial that deepen our understanding of how they might unfold and what can be done to mitigate their severity, especially since the prospects of the needed near-term world-assemblage transition to sustainability appear increasingly dim.

There are at least three possible scenarios for a global collapse trajectory: 1) neoliberalism remains hegemonic despite worsening financial-oil-food shocks, which provoke "growth at all costs" strategies that deliver diminishing returns, and the global economy collapses into a "terminal depression" from which it cannot recover (unfolding between 2020 and 2040); 2) neoliberalism remains hegemonic and critical energy shocks are avoided due to rising output from unconventional oil, though this leads to accelerating climate change and catastrophic impacts on global food and financial assemblages, thereby catalyzing a spatiotemporally uneven global collapse between 2050 and 2080 (or perhaps later, depending on the speed of climate change);[163] and 3) a global GND regime fails to restore growth due to a combination of energy constraints, excessive debt accumulation, weak profitability, insufficient job creation, and/or carbon bubble shocks,

[163] This "long-term collapse" scenario maps onto Jorgen Randers's forecast, which anticipates no discontinuous systemic shifts before 2050 but a period of climate chaos and likely systemic collapse in the later part of the century (Randers, 2012).

provoking relapse into a "growth at all costs" mode that drives a slower yet ineluctable process of runaway warming and world-assemblage breakdown after mid century.

To describe the first possible scenario: a combination of financial, food, and energy shocks undermine the foundations of the global economy and overwhelm governmental efforts to restore confidence. The anticipations of energy abundance from unconventional fossil fuel reserves fail to materialize, with economic contraction and sluggish demand making their exploration and extraction unprofitable. Therefore, the fossil fueled basis of economic growth reaches the limits of viability, while inadequate investment in renewable energy fails to make up for the shortfall. The US and EU governments stick to similar crisis-fighting strategies by trying to bail-out the financial and fossil fuel industries, though soaring debt to GDP ratios combined with generalized anxiety towards the future (fuelled by worsening climate impacts) leads to failure to restore confidence and provokes significant inflationary (if not hyper-inflationary) trends (Ahmed, 2017: 85). Investment, trade, and consumer demand collapse, states turn inward to prioritize the needs of their own populations, and the livelihoods of states dependent on imported food, energy and water become critical as prices rise with exports taken off the market. Fuel and food prices spike, as they did in 2008, with the worst effects felt in fragile states throughout peripheral regions. States from Latin America to Africa, the Middle East, and Southeast Asia are further stressed by a combination of climate change impacts and dwindling export revenues, which feeds into ongoing cycles of violent conflict and mass migration (Ahmed, 2017). These processes in turn feedback on economic instabilities in the core, where nation-states like the US not only face worsening economic crisis comparable to the great depression but also rising costs to deal with intensifying extreme weather, drought, and plateauing food production. The structural fragilities of rising powers like China[164] and India become apparent (e.g. dependence on oil and food imports, environmental deterioration, high levels of debt, and social tensions from rising inequality), while the US and EU are too concerned with their own domestic crises to focus their efforts on restoring global stability (ibid: 67-87). Social unrest intensifies across the globe, militarized policing kicks into high gear as governments strain themselves to maintain civil order, emergency services are constrained by energy shortages and the sheer magnitude of the crises,[165] and world order progressively erodes via self-serving security measures by states, communities, and individuals looking to fend for themselves.

We can hope that a process of global collapse would be drawn out enough such that its early phases could catalyze the self-organization of more sustainable modes of collective individuation at local, national, and regional scales, which could perhaps even catalyze the emergence of an ecosocialist world-assemblage. Indeed, the needed widespread support for something like an ecosocialist transition may only be possible in an early phase collapse trajectory, which may catalyze a series of emergency measures (e.g. rationing of food and energy) that push nation-states towards ecosocialist degrowth attractors. However, the collapse process can also become auto-catalytic and self-amplifying, with ties between individuals at all scales – international, sub-national, and

[164] While many economists and IR scholars believe an ascending China may be able to underwrite a stable capitalist economy as Western power declines, Minqi Li and others show that a biophysical analysis of their power basis should make us skeptical: China's domestic oil production will soon peak (potentially as early as 2018), making it increasingly dependent on oil imports as supply shocks become more likely; and it is already in the throes of a water crisis – driven by a combination of climate change, over-pumping, and industrial pollution – that will strain its agricultural capacities and enhance its dependence on food imports (Li, 2016; Ahmed, 2017: 73; Brown, 2012: 91-92; Wang et al, 2017).

[165] For example, Cindy Parker and Brian Schwartz argue that energy scarcities in the future will result in reduced capacities and services in health care and public health systems. Hospitals are energy intensive assemblages, requiring advanced diagnostic technologies and patient-care equipment around the clock. Therefore, they warn that the connections between the global just-in-time economy, energy availability, and public health are "far more extensive than almost anyone can imagine" (Parker & Schwartz, 2010: 393).

communal – weakening as specific states, communities, and individual humans struggle to secure their own livelihoods at the expense of others. The U.S. military is already preparing for such disorder, with a recent report warning that military operations abroad may be overwhelmed by fuel and water shortages combined with the sheer number and magnitude of crises demanding emergency response (Ahmed, 2019b), whereas their "Minerva Project" aims to anticipate social unrest at home in order to stymie the likely protests that will emerge as these crises intensify (Ahmed et al, 2015). Though some resilience analysts believe that wealthy states and cities in the global north would be very resilient to such shocks (Grosvenor Group, 2014), others are less sanguine, given not only the intense reliance of these states on cheap oil and fragile global supply chains, but also the weakening of communal ties under rampant neoliberalization in which bonds of community trust and reciprocity have often succumbed to commoditized relationships and individualized households looking to fend for themselves (not to mention having lost basic skills in livelihood provision due to dependence on the global market) (Homer-Dixon, 2006).

In short, while a process of world-assemblage collapse would be spatiotemporally and intersectionally uneven (devastating disadvantaged race-class-gender populations first, as we are already witnessing), it would impact all regions and leave no one fully immune from the insecurities it would generate. We should not assume that the great powers of the global north – with their wealth and power built on fossil energy, financial engineering (or what Marx called "fictitious capital"), and exploitative economic relationships with the global south – would be unaffected or even less affected than (some) peripheral communities who have at least partially retained sources of resilience that pre-exist the neoliberal capitalist assemblage (Kuecker & Hall, 2011).

The Molecular and Molar Violence Problematic

It is worth investigating the structure of the SEP taken by itself, since it already poses a formidable predicament that is likely to result in a catastrophic bifurcation for the capitalist world-assemblage as a whole and may even precipitate the collapse of core states in North America and Europe. However, the predicament deepens when we situate the SEP in relation to the Molecular and Molar Violence Problematic (MMVP) with which it is entangled. As indicated in chapter one, the key parameter that links the SEP with the MMVP is technological change, which is itself subject to intensive thresholds where technoscientific breakthroughs and/or positive feedbacks between mutually-enabling technologies rapidly create new vistas of innovation (Deudney, 2007). As previously discussed, such thresholds of technological change in numerous sub-domains – including synthetic biology, 3d printing, the internet-of-things, and artificial intelligence – will likely be necessary for a continuously expanding Green Neo-Keynesian capitalism to be viable. The possibility of such a solution will not be dismissed here, but the urgent question then would be understanding how such solutions would shift problems onto the MMVP by creating a new class of technological risks and security threats that may catalyze a catastrophic world-assemblage bifurcation on their own. In short, an exponential "Fourth Industrial Revolution" may be needed to resolve the SEP within the framework of global capitalism (Schwab, 2017), but in doing so it will intensify the MMVP to the point of a catastrophic bifurcation that would threaten to extinguish or (more likely) severely restrict the future conditions of collective individuation for humanity.

As discussed in the previous chapter, the dominant solution to the contemporary MMVP is a "liberal" global security assemblage that integrates the surveillance capacities and intelligence agencies of the U.S. and its European allies, relies on inter-state cooperation to manage non-state terror and criminal threats, blurs international and domestic policing agencies, and acts under at least the semblance and partial constraints of domestic and international law (Bigo, 2006; Zappala, 2015). It is possible that this assemblage is *already* on the cusp of a bifurcation, which could be triggered by a major non-state terrorist attack leading to significant constraints on democracy in the US, Europe and elsewhere (Deudney, 2010), though this danger will only intensify as molecular and molar violence capacities accelerate. As security analysts like Blum and Wittes fear, technological trends (driven by the Fourth Industrial Revolution) may signal that "the state itself may be losing its ability to serve its purpose as the ultimate guarantor of security to its citizens" (Blum & Wittes, 2015: 6). While we should of course recognize that states have always acted to secure particular bodies and spaces at the expense of others, as the record of institutional racism and police brutality towards people of color in the U.S. and elsewhere makes clear, it is also important to recognize that emerging forms of molecular violence unleashed by the FIR may overwhelm the capacities (let alone willingness) of present-day military-security to manage these threats, thereby creating immense pressures for even more totalizing and penetrating apparatuses. Therefore, even before situating these processes within a more multi-dimensional analysis that includes earth system turbulence and political-economic inequality, it appears that the securitization capacities of contemporary states and global security assemblages are already being stretched by the emergence of complex new molecular threats,[166] which are forcing them to reorganize and may catalyze a catastrophic bifurcation towards more draconian security assemblages in response to new attacks.

As noted previously, this discussion of the MMVP will focus on the Green Neo-Keynesian scenario, since it represents the most "continuationist" solution to the SEP, and scholars have barely begun to systematically consider the problems of violence-interdependence it would create.[167] However, the MMVP would also take unique forms in the ecosocialist and collapse trajectories, and it is therefore worth investigating the security assemblages that might emerge in these scenarios.

Parameters and Dependency Relations

The key parameters of the MMVP, in part following Deudney, can be mapped as the relations between geography and technoscience (i.e. "violence-interdependence"), infrastructure-density, relations of structural violence, and the cognitive-affective landscape (e.g. the prevalence of collective affects like fear and anxiety). Additionally, we can characterize the structure of global security assemblages according to their "relations of protection" (i.e. the relations between "protectors" and "protected", which can take more and less hierarchical and authoritarian forms), technologies of securitization, and the legal-institutional forms that mediate relations between

[166] The rise of practices of "speculative preemption" (Cooper, 2011: 83), in which security agencies attempt to anticipate and prepare for a diverse array of catastrophic scenarios, often employing Hollywood directors and writers, should be understood in relation to this changing technological context.
[167] Environmentalists discussing the security consequences of nuclear energy expansion mark a clear exception to this tendency (e.g. Green, 2015), but there has been much less consideration by environmentalists of the threats posed by other FIR technologies.

"protectors" and "protected". For understanding critical transitions, the key parameter for our purposes is violence-interdependence (VI) (both molar and molecular), though we need to foreground how it interacts with structural violence, SEP parameters like climate and energy, and cognitive-affective assemblages. For example: structural violence enhances the likelihood of eruptions of molecular violence, which in turn tends to intensify the molar violence of states to constrain this violence; climate change may fuel molecular terrorism by disproportionately impacting poor populations from the global south who are most vulnerable and least responsible (especially if northern states try to significantly restrict migration through militarized borders); energy depletion would constrain molar violence potential by restricting the force mobilization capacities of states across geographic distance; energy abundance, on the other hand, would enable high levels of automation across the global economy, would increase technological unemployment, *may* intensify structural violence (if sufficient policies to address the fallout are not adopted), and thus exacerbate molecular violence as a result; finally, collective affects like fear and anxiety, likely intensified by a combination of climate change and molecular violence outbreaks, would make democratic populations more willing to accept intensified molar violence as the cost of (at least perceived) security.

To begin, in the context of a Green Neo-Keynesian solution to the SEP, we should recognize that even a best-case version of a global GND would entail significant levels of structural violence, earth system turbulence, and social unrest. Controls on global finance and enhanced autonomy for local and national development priorities would help palliate social unrest and improve political-economic stability in states and regions of the global south. But this must still occur within a context of 2°C of climate change that may still leave 16 to 29% of the world's population (mostly in the global south) vulnerable to lethal climate impacts (Byers et al, 2018). FIR breakthroughs could certainly improve adaptation capacities even amidst such environmental changes, but poverty and deprivation would remain difficult to reverse, and deep grievances felt towards the global north – due to its primary responsibility in creating the problem whose consequences are primarily suffered in the global south – will make militant and/or terrorist violence a likely response. We would in this sense be experiencing a situation of continuous degradation of socio-ecological assemblages for up to a third of the world's population (though this is subject to much uncertainty) along with the existence of deep grievances felt towards states in the world-assemblage core and the proliferation of new technologies of mass destruction.

At the same time, a world of exponential FIR-driven technological change would witness a significant displacement of human labor through the automation of work, which some studies predict will displace up to 45% of jobs (at least in the US and Europe) over the next 20 years (Frey & Osborne, 2013).[168] Therefore, even if a Green Neo-Keynesian regime were able to continuously grow through a new regime of cheap energy, cheap food, and carbon neutral forms of accumulation, it would eventually be forced to confront the problem of technological unemployment. If 38% percent of jobs are indeed automatable by the early 2030s, and 40-50% by 2040 (as Kai-Fu Lee suggests), this means that actual levels of technological unemployment could reach 20-25% between 2040 and 2050 (depending on the speed of worker replacement and new job creation)

[168] Economists are divided on this question. A 2016 study by the OECD, which followed a different methodology by breaking down jobs into a multiplicity of tasks and considering what tasks can and can't be automated, countered that just 9% of jobs in the US will be at risk of automation (Lee, 2018: 159). However, Kai-fu Lee provides a strong argument for why the higher numbers (40-50% of jobs at risk) are more likely: instead of just focusing which existing jobs in current industries can be automated, Lee shows that we must also consider how AI will drive industry wide disruptions by creating whole new models of delivering services that rely on few to zero employees (ibid: 162-163).

(Lee, 2018: 164). Whether such levels of technological unemployment would be compatible with the survival of capitalism is one question, which is at least feasible if a Universal Basic Income or similar policies are adopted.[169] But the key question, for our purposes, is whether such policies would be adopted in time (or provide a sufficient source of income) to ward off the "tremendous social disorder and political collapse stemming from widespread unemployment and gaping inequality" created by automation (ibid: 20-21).

Furthermore, while the structural violence of core-periphery inequality (particularly in a 2°C world), climate change, technological unemployment may create the preconditions for molecular terrorism (e.g. among white supremacists, eco-fascists, religious fundamentalists, cults, revolutionary groups, and others), FIR technologies would be cheapening and democratizing access to WMD capacities. For example, as discussed in chapter one, the incipient threat of biotechnologically enhanced bioweapons is arguably the most serious molecular violence threat on the near-term horizon, which creates a "virtually limitless" threat landscape (Vogel, 2008: 234). As discussed in chapter one, open-source gene editing technologies continue to advance and cheapen, and we should consider whether or not an intensive threshold in this process exists: at one point does the availability, cost, and sophistication of synthetic biology *non-linearly* increase the possibility of a catastrophic attack?[170] Similarly, we have already crossed a

[169] On this question see Randall Collins (Collins, 2013), who concludes that the mechanisms through which past waves of automation were made compatible with capitalist stability have been exhausted, and that automation will therefore most likely tip nation-state economie towards socialism.

[170] Kathleen Vogel tries to counter catastrophist bioterror narratives by emphasizing that "technologies emerge within social, natural, economic, and political contexts", rather than marching "steadily forward, undeterred by social and technical circumstances" (Vogel, 2013: 47-48). This is not wrong, but unfortunately her case against panic (for those of us afraid of the bioterror threat) is unpersuasive, since it ignores the very real trends towards increasing availability and reduced costs of open source biotechnology, as well as the likelihood of non-linear advances driven by mutually reinforcing breakthroughs in nano, bio, and information technology. It is not enough to make the (fairly obvious) point that technologies are conditioned by political-economic contexts; in the case of biotechnology, one must make a case

threshold of connectivity in cyber-infrastructures and availability of attack vectors that has made cybersecurity an increasingly serious problem, though we should consider whether there might exist further thresholds driven by the "Internet of Things" and rise of "Smart Everything" (Falk et al, 2018) (likely needed to maximize energy efficiency and the potential of renewable energy, as discussed in chapter one) that would make a catastrophic attack more likely (Goodman, 2016). Similar thresholds could be envisioned regarding the diffusion of 3d printing, which is already improving access to firearms and could make it possible for biohackers to print genes (NAS, 2018), as well as in nuclear energy. Is there a critical point at which increasing dependence on nuclear energy and the availability of nuclear waste would non-linearly increase the threat of nuclear terrorism? In the same way that complexity ecologists recognize the existence of a critical threshold in the density of dry material in a forest beyond which the potential for conflagration dramatically increases (Scheffer, 2009: 76), so might there exist critical thresholds in the availability and diffusion of new violence capacities. Meanwhile, the growing prevalence of "smart cities" and AI would contribute to the further development and refinement of technological apparatuses of molar securitization, which will be considered increasingly necessary to police emerging threats in the domains of nuclear, bio, and cybersecurity (Deudney, 2007; Bostrom, 2018).

A crucial point to recognize is that the virtual phase space of the MMVP is structured by all these processes simultaneously. Therefore, it only takes crossing an intensive threshold in a single technological sub-parameter to catalyze a catastrophic

for why this context is likely to slow down (rather than accelerate) technological advance, which Vogel fails to do. Of course, as discussed in the previous section, a political-economic depression and collapse could be a powerful negative feedback that slows and reverses biotechnological advance, though efforts to devise a Green Neo-Keynesian resolution could just as well catalyze an acceleration of biotechnological advance (e.g. via state-directed research and development in biofuels, genetically modified organisms, bio-materials, biotech medicine, etc.)

bifurcation, or even merely a combination of continuous quantitative shifts in all of them simultaneously. In other words, it is not simply a matter of passing a threshold in nuclear, bio, or cyber vulnerability, but more a matter of the relations and feedbacks between them all, which will create intensive pressures that may force a catastrophic bifurcation. One sub-parameter could do it if there's a major nuclear, cyber, or bio attack; or they could all do it together if an accumulation of small or medium-size attacks in all three areas combine with intensifying molar violence capacities to force a bifurcation. And given that these are *synergistically amplifying technologies*, we should expect that breakthroughs in each FIR parameter will contribute to further breakthroughs in the others. In conjunction with continuous advances in technologies of securitization (e.g. more powerful data collection and processing capacities) and weakening legal-institutional constraints on the exercise of these technologies, alongside rising fear among governed populations, it may only require a relatively "minimal" attack (e.g. something comparable to 9/11, rather than the kind of million or even billion casualty attack feared by some bioterror experts) to provoke such a bifurcation. Thus Deudney concludes that, even in present conditions of violence-interdependence, "a catastrophic terrorist attack is likely to trigger a deep further abridgement of the limited government constitution of the United States" (Deudney, 2010: 299), and we will likely confront further thresholds of securitization at both national and global scales as molar and molecular violence capacities advance.[171]

[171] The relation between critical thresholds in security assemblages at national and global scales is an under-explored issue in this dissertation that I will consider in more depth in future work. Given that they are less globally systemic than political-economic life-support assemblages, their transitions will be more geographically uneven. But we can expect that a critical transition in the security assemblages of China and the United States would provoke comparable transitions at least across their European, South American, African and East Asian spheres of influence.

Overall, we can identify a dangerous feedback loop in which SEP crises, structural violence, and molecular violence capacities combine to spread anger, fear and anxiety among populations, with security agencies driven by new levels of paranoia to surmount legal and technological constraints on their exercise of molar violence. I refer to this process as a *spiral of molecular insecurity and molar securitization*, in which emerging molecular threats bring forth intensified molar violence to try to contain them, which may in turn provoke even more molecular violence by intensifying state violence and repression. The rise of practices like "speculative preemption", "vital systems security", and "virtual security" documented by Foucauldians illustrates that such a spiral might already be in motion, witnessed in rising levels of "paranoia" among security agencies resulting from emerging molecular threats (Cooper, 2011; Collier & Lakoff, 2008; Evans, 2013). Brian Massumi and Melinda Cooper emphasize the *affect* that these "virtual" (i.e. not-yet-actual) threats generate. Whereas a virtual threat may not have an actual referent in the world as presently constituted, it has "actuality" to the extent that it has an affective quality that "legitimates preemptive action" in the present, even though the threat may be based primarily on speculation (Massumi, 2010: 54). In this way, as Cooper writes:

> the new discourse of catastrophe risk establishes our affective relation to the future as the only available basis for decision making, even while it recognizes the inherently speculative nature of this enterprise. What it provokes is not so much fear (of an identifiable threat) as a state of alertness, without foreseeable end (Cooper, 2008: 83)

While Foucauldians tend to downplay or ignore the material-technical reality behind these shifts in security governmentality, their analyses alert us to what are perhaps the early phases or signs of an imminent bifurcation in (and consequent reorganization of) global security assemblages. Even in the absence of *actualized* molecular violence, the virtual threat landscape composed by the differential relations between FIR technologies and networked critical infrastructures is already affecting the structure and functions of these assemblages. If we could see the virtual phase space that structures the MMVP, we might perceive a shrinking attractor basin for the contemporary "liberal" organization of global security assemblages and the emergence of a new attractor separated by a catastrophe fold, which is already exerting "gravitational" effects on the former (via affects of fear and uncertainty) and is likely to be actualized should a catastrophic attack (or even a series of lesser attacks) emerge.

The MMVP Solution-Space

Planetary Techno-Leviathan

In this scenario, thresholds crossed in molecular violence capacities, powers of molar securitization, and willingness of northern populations to accept draconian restraints on individual and collective freedoms combine to create a "Planetary Techno-Leviathan"[172] (PTL) with unprecedented vision, lethality, and force-mobilization capacities. While the current globally hegemonic mode of protection has clearly already crossed something like a threshold of intensification since 9/11, the PTL would involve a *further* threshold of planetary securitization catalyzed by the FIR-driven insecurity-securitization spiral. One key question is whether this would be compatible with the consistency of a "capitalist" world-assemblage. In the abstract, we could say that such a threshold would involve a transition from capital accumulation to security as the main

[172] This concept is inspired by Geoff Mann and Joel Wainwright's concept of "Climate Leviathan" (Mann & Wainwright, 2018), which is in conversation with the broader literature on world government.

organizing principle of the world-assemblage – in other words, security would become the "ecologically dominant" assemblage through which world order is reproduced (Jessop, 2000), which would shape and constrain socioecological, cognitive-affective, and legal-institutional assemblages more than the latter are capable of shaping and constraining the former. However, it is debatable whether this would truly constitute an intensive threshold that provokes a qualitative reorganization of the world-assemblage's identity, structure and feedbacks, or simply a continuous shift that intensifies ongoing trends.

Assuming there *does* exist such a threshold, at one point could we say it has been crossed? The most obvious way to define such a threshold would be to identify a shift from a "liberal" mode of protection to an "authoritarian" mode that establishes a permanent "state of emergency" on a planetary scale. Following Sven Opitz's Foucauldian analysis, this could be viewed as a threshold between liberal and illiberal "security dispositifs", or between those that function within the bounds of law to maintain certain freedoms and those that install a sovereign exception to liberal rule (Opitz, 2011). This would involve a conjoined transformation in and integration of both technological-surveillance and institutional-legal assemblages, with the former being intensified and extended (perhaps even to the level of neurobiological monitoring) and the latter shedding all pretext of democratic oversight in order to become an explicitly absolutist form of sovereign authority on a planetary scale. Surveillance would reach from the planetary to the molecular scale through a networks of satellites, distributed environmental sensors, and AI-facilitated data collection and processing techniques; military force-mobilization capacities of nearly absolute speed and global reach could be created through a combination of space-based and networked AI-robotic weapons systems; and the right of the planetary sovereign to detain individuals, mobilize force without legal pretext, and constrict the mobility of people and goods to more tightly regulated territories, would be enshrined.[173]

Conceptually speaking, the creation of a Planetary Techno-Leviathan in this manner could entail the actualization of Arrighi's prediction of a "truly global empire" imposed through American military and technological power (Arrighi, 2010: 23). However, in my view it would emerge less as a direct response to political-economic crisis than as a "solution" to the planetary disorder fueled by earth system destabilization, intensified flows of molecular violence, and political-economic elites unwilling to cede wealth and privileges to resolve structural violence. My analysis is closer to Geoff Mann and Joel Wainwright's argument that current political-economic and earth system trends are pushing towards the creation of a "Climate Leviathan", which they claim would "seize command, declare an emergency, and bring order to the Earth, all in the name of saving life" (Mann & Wainwright, 2018: 31). But our analyses differ in that they focus on the global systemic pressures towards a "Keynesian world state" created by the contradictions of capitalism and the pressures toward emergency climate governance (potentially through geoengineering), whereas they don't consider the role of FIR technologies and the resulting spiral of molecular insecurity and molar securitization in bringing this Leviathan to fruition.

[173] While such an apparatus may seem far-fetched, philosopher and futurist Nick Bostrom envisions a similarly totalitarian global surveillance system as the necessary prerequisite of global security in an age of democratized weapons of mass destruction (Bostrom, 2018). And he notes that "thanks to the falling price of cameras, data transmission, storage, and computing, and the rapid advances in AI-enabled content analysis, [it] may soon become both technologically feasible and affordable" (ibid: 25).

The emergence of a PTL could also be understood as what Deleuze (following Foucault) might call a transition from "control" to "discipline" as the primary function of global security assemblages. As Deleuze explains, the former involves "ultrarapid forms of free-floating control" that manage population movements and flows in an open space of circulation (Deleuze, 1992: 4). Control is thus largely congruent with what Foucault understood as the *liberal security dispositif* (or apparatus/assemblage), which was primarily concerned with "allowing circulations to take place, of controlling them, sifting the good and bad, ensuring that things are always in movement, but in such a way that the inherent dangers of this circulation are canceled out" (Foucault, 2007: 65). "Discipline", on the other hand, relies on spaces of enclosure that facilitate the imposition of strict behavioral regimes; it individualizes subjects according to a well-defined norm and seeks to internalize discipline by submitting them to a continuous gaze (Foucault, 1975). In this sense, a transition from control to discipline as the primary "diagram"[174] through which security assemblages function could involve planetary-wide surveillance, ironclad borders, constricted mobility, and perhaps even the use of incipient neuro-technologies and mind-alteration techniques to monitor and mold individual subjects.[175] However, as Foucault emphasizes, governmentality transitions don't simply involve the *replacement* of one mode by another (e.g. the replacement of discipline with liberal apparatuses of security), but rather their reconfiguration to reflect a new set of priorities, a "change in emphasis", that alters their dominant characteristics (Foucault, 2007: 8). In this sense, a transition from liberal apparatuses of security/modes of protection to more authoritarian

[174] As Deleuze explains in his reading of Foucault, organizations of power-knowledge form a "diagram" – a complex and emergent "strategy" of power – that can be actualized in different contexts (Deleuze, 1988: 72). For example, the disciplinary diagram could be seen at work in factories, schools, militaries, and families.

[175] Frighteningly this is slowly becoming more than science fiction: see Elon Musk's "Neuralink" venture, which is currently developing brain-computer interface technologies that may be capable of translating people's thoughts into words (Lentzos & Butorac, 2020).

and disciplinary forms would not simply involve a replacement of the former by the later, but rather their transformation and integration in a novel assemblage with a qualitatively different set of relations, feedbacks, and functions.

I believe such a transition would warrant the concept of "catastrophic bifurcation", since it would constitute a radical reorganization of the structure, functions, and feedbacks of both security assemblages and the world-assemblage as a whole that would be incredibly difficult (if not impossible) to reverse, thereby exhibiting hysteresis. This does not mean it would put an end to capital accumulation, though it may constrict and constrain it to such a degree that it would no longer form the "ecologically dominant" organizing principle of the world-assemblage (Jessop, 2000). In other words, rather than economic growth and globalized trade forming the primary goals of states and political-economic elites, "security" would become the overriding imperative, and the circulation of people, goods, and economic activity more generally would be circumscribed to the extent deemed necessary by the sovereign to prevent outbreaks of molecular violence. Corporations would retain much of their control over the planet's productive resources, though they would become servants more than masters of techno-authoritarian states, with technology companies like Google and Facebook becoming more the architects and operators of planetary surveillance assemblages (rather than private enterprises focused on profit maximization). Such a "post-capitalist" transition would be reinforced by the likely unavoidable trend towards technological unemployment in such a scenario, with the diminishing importance of wage labor combined with intensified fear and desires for security among populations making capitalism less central to the daily lives of most. In this sense, we would witness a world where security has displaced capital accumulation as the primary function of world-assemblage governance, and where wage labor is no longer the primary form of social reproduction for much if not the majority of populations (at least in core countries where the cutting edge vectors of automation reside). Some (depending on their working definition) might continue to refer to such a world-assemblage as "capitalist", but this would be a circumscribed capitalism in which the systemic imperative to maximize private profit would no longer be the primary engine of "growth" and technological progress.[176] Earth would be significantly degraded, the world's remaining peasantries would be dispossessed, the vast majority of the world's population would live in tightly monitored and policed mega-cities, and it would probably not be a world in which most of us would prefer to live (though better and worse formations are possible).

Decentralized Ecosocialist Security Assemblages

It is worth briefly considering how an ecosocialist resolution of the SEP would entail a different configuration of the MMVP. An ecosocialist solution could be actualized in at least two general forms: an "ecomodernist" form with a similar technological base, material-energetic throughput, and globally networked complexity as the Green Neo-Keynesian form just explored, which is proposed by Marxists like Nick Srnicek, Alex Williams, Leigh Philips, Peter Frase, and Aaron Bastani (Srnicek & Williams, 2015; Frase, 2016; Philips, 2015; Bastani, 2019); or a "degrowth" form, which

[176] Whether "growth" would continue in this formation, and in what sense, is a challenging question. As previously discussed, multiple studies convincingly demonstrate that an "absolute decoupling" of growth from growing resource use is likely to prove impossible (Kallis & Hickel, 2019; Parrique et al, 2019; Ward et al, 2016; Wiedmann et al, 2015), which means that limits to rising material-energy throughput will most likely be reached sometime during the 21st century (as the Club of Rome predicted) (Meadows et al, 1972). However, it at least seems plausible that an exponential "Fourth Industrial Revolution" could unleash abundant energy from renewable and nuclear sources, along with economical techniques for exploiting outer space resources and colonizing extra-terrestrial bodies. In this case, "growth" understood in terms of rising material-energy throughput may indeed continue, though it would no longer be primarily driven by systemic imperatives to maximize private profit, job creation, and tax revenues. While perhaps unlikely (certainly from the vantage point of ecological economistS), it cannot be completely dismissed as a possible future.

would entail a world-assemblage configuration with reduced material-energetic throughput, localized production of critical resources like food, energy, and basic medicines, and diminished global complexity, such as explored by ecosocialists like Richard Smith, Sarel Sarkar, Ian Angus, Michael Lowy, and John Bellamy Foster (R. Smith, 2016; Sarkar, 2012; Angus, 2016; Foster et al, 2011; Lowy, 2015) along with degrowth scholars like Georgos Kallis, Ted Trainer, Jason Hickel, Richard Heinberg, and Juan Martinez Allier (Kallis, 2018; Trainer, 2010; Hickel, 2017; Heinberg & Fridley, 2016; Martinez Alier et al, 2010).[177] I will assume that the ecomodernist mode of ecosocialism would entail a comparable configuration of the MMVP as the Green Neo-Keynesian resolution. While it would hypothetically entail much greater equality at least within the core states of the global north, thus improving well-being, mental health, and reducing the likelihood and frequency of molecular violence outbreaks (at least in their human intention-originating forms), it would likely also continue extractivist relations with peripheral regions of the global south and elsewhere to produce its materially and energetically intensive infrastructures. Thus it would most likely perpetuate a world in which both the capabilities and desires exist to unleash mass casualty attacks on civilians, which would risk undermining the democratic gains of ecosocialist regimes by tipping them into powerful molar securitization machines comparable to their current forms.

[177] Schwartzman and Schwartzman can be considered a middle ground eco-socialist position between these two poles, since they acknowledge the need for material-energetic degrowth in the rich countries of the global north but argue that total resource use will need to increase to provide all humans with a "state of the art" standard of living (Schwartzman & Schwartzman, 2018). They challenge the arguments of Trainer, Heinberg, and others who believe that renewable energy will not be able to supply growing energy needs. Whether or not they are right boils down to a technical question concerning the overall potential of renewable energy that I am not competent to adjudicate. Yet their enthusiasm for asteroid mining as a way to sustain "necessary extractivism" breeds skepticism – asteroid mining has so far proven uneconomical *even in the era of cheap fossil* fuels, and it appears unlikely that renewable energy will allow us to become a space-faring civilization (Deudney, 2020). Furthermore, Schwartzman and Schwartzman critique Richard Heinberg for ostensibly ignoring Mark Jacobsen's studies demonstrating the feasibility of a 100% renewable transition (ibid: 97, 113), though this ignores Heinberg's 2016 co-authored book with David Fridley, which *does* explicitly engage with and critique Jacobsen's arguments in this regard (Heinberg & Fridley, 2016: 58, 121-122).

A degrowth or low-throughput mode of ecosocialism, on the other hand, would likely be the ideal resolution of the Planetary Problematic as a whole, encompassing the SEP, MMVP, and EP. Not only would such a world-assemblage (in the ideal) enable a genuinely sustainable long-term resolution of the SEP by institutionalizing political-economic selection-pressures that systematically pursue ecological regeneration: it would also enable "contraction and convergence" with the global south to amend the imperial relations of structural violence that have defined north-south relations since the 19th century, which would be by far the most effective way to "fight terrorism" (Abbott et al, 2007; Rogers, 2008). A global eco-socialist assemblage marked by greater localization of socio-ecological assemblages and acceptance of low throughput lifestyles would also go a long way towards mitigating military competition, in particular by removing the incentive for control of distant resources (mainly oil, but also rare earths and other minerals) through neo-imperialist strategies, thereby critically weakening the power of the military-industrial complex and enabling its immense resources to be channeled to more sane and productive uses (Schwartzman & Schwartzman, 2018).[178] Furthermore, a more localized eco-socialist world-assemblage would significantly reduce the technological and systemic risks driven by exponential technologies and global interconnectivity (including pandemics). This is because production and maintenance of critical life-support functions would be primarily localized (thereby enhancing world-

[178] However, ecosocialists will need to think more carefully about how to engage with military institutions, as Quincy Saul consels (Saul, 2011). Ecosocialists typically hope that they would be completely abolished (Schwartzman & Schwartzman, 2018; Smith, 2016; Angus, 2016), which would be nice. But so long as there are powerful states in the world-system who have not at the very least adopted a cooperative, non-militaristic, and pro-climate mitigation foreign policy (e.g. Russia), then it will likelybe necessary to retain at least some form of military power for deterrent purposes. But this could entail a radical retrenchment of polluting, wasteful, and unnecessary arms production; a rapid reduction of nuclear arms to the bare minimum needed to sustain deterrence; and an institutional and ideological restructuring of the military to focus on disaster response and relief efforts. This is of course a tall order (to put it mildly), and we should not underestimate the commitment among military personel to upholding a racial capitalist world order (Buxton & Hayes, 2015), but it at least appears more feasible than the abolitionist vision.

assemblage "modularity"), the circulation of people and goods would be reduced,[179] and the elimination of expansionary economic pressures would enable communities to pursue lower-energy livelihoods that don't rely so heavily on FIR technologies.

Yet molecular threats would clearly remain. The violence of persistent extreme weather would require various forms of emergency planning and response, though the experience of Cuba suggests that an ecosocialist regime would potentially be far more adept at disaster response than their capitalist counterparts (N. Smith, 2007). Perhaps most dangerously, various forms of "neo-fascism" that hearken back to a golden age of fossil fuel abundance would likely try to sabotage these regimes with whatever means remain at their disposal. Thus new forms of policing will remain critical, ideally through community-organized strategies that can attenuate the molar violence of past regimes while enabling new forms of self-regulation through decentralized surveillance and other institutions (Rameau, 2017). A functioning global info-sphere will remain critical and will thus undoubtedly remain vulnerable. However, the liberation from commercial pressures to intensify network density and speed could make the adoption of something like Ron Deibert's strategy for cyberspace more plausible by strengthening "epistemic communities" of civilian cybersecurity experts relative to states and corporate ICT monopolies (Deibert, 2014).[180] Open source synthetic biology techniques may be

[179] This may seem to be difficult to reconcile with a progressive approach to immigration and refugees, though the ideal would be to enshrine a right to mobility and resettlement in spaces of the global north in order to escape conflict and climate chaos. Far-flung supply-chains and extractive tourism, and thus the overall circulation of people and goods, however, would be significantly reduced (in an eco-socialist world-assemblage there would be no need for countries to rely on tourism to sustain their livelihoods) (Fletcher et al, 2019).

[180] In Deibert's description: "When it comes to policing cyber security threats—such as botnets, malware, and threats to critical infrastructure—distributed security provides a model for the enhancement of the best parts of existing practice…Building resilience into the design of cyberspace begins with empowering locally rooted but highly connected experts", which would entail "a semipermanent, voluntary negotiation system that allows interdependent actors to opt for collaboration or unilateral action in the absence of an overarching authority" (Deibert, 2014: 49). While the current trend is toward greater state involved, hybrid networked-hierarchical practices, growing secrecy, and politicization of technical standards, what Deibert describes as an RST cybersecurity strategy "would seek to reverse this process, immunizing cyber security epistemic communities from national rivalry while building out the local

necessary, or at least valuable, for regenerating particular ecosystems, creating locally adaptive and resilient crop varieties, and enabling new forms of decentralized and open-source medicine (in combination with 3d printing) (Urry & Birtchnell, 2013), which would thus create biosecurity risks. These risks arguably should be accepted given the likely benefits of open source synthetic biology and 3d printing in a relocalized and energy-constrained world-assemblage, though its reduced complexity, connectivity, and structural violence would fortunately make them both less potentially devastating and less likely to occur. Still, networks of bio-surveillance will be needed, perhaps following similar principles as those advocated by Deibert for a decentralized cybersecurity strategy.

Overall, the global security advantages of a low-throughput eco-socialist order would not only include its reduction of structural violence and is more modular structure of socio-ecological assemblages, but also the greater democratic control it would afford over the pace and direction of technological change. In most security analyses, the underlying technological trends driving new forms of violence-interdependence are often taken for granted rather than taken as objects of critical interrogation. For example, after describing the vast range of possibilities by which non-state terrorists could bring capitalist civilization to its knees, Homer-Dixon concludes that little can be done about their "inexorably rising capacity for violence", which results from "deep technological forces that can't be stopped without producing major disruptions elsewhere in our economies and societies" (Homer-Dixon, 2002: 61). While he is certainly correct that

capacities of these fora across global regions, extending peer security production, and then shielding the network from co-optation by partial state or corporate interests" (ibid: 50). Deibert does not consider the plausibility of this vision in the context of contemporary neoliberal capitalist hegemony, nor how converging socioecological crises will impact the field of cybersecurity. But attention to such considerations should provoke us to imagine ecosocialist resolutions of the SEP that incorporate the kind of decentralized cybersecurity strategy he envisions.

these trends would be very difficult to reverse, such claims ignore how technological forces could be redirected and constrained through political-economic transition, and therefore risk naturalizing rather than politicizing them. The current trajectory of technological evolution involves minimal collective intelligence, long-term planning, or self-regulation in its directionality, and is instead driven by the "anarchy of the market" and military competition (Rosenberg, 1994). Rather than simply fatalistically accepting the need to adapt to these "deep technological forces" beyond our control, we should instead recognize that this is fundamentally a political-economic matter that *can* be transformed by transitioning to alternative systemic organizing principles.

Exterminist Bunkers, Violent Survivalism, and Cooperative Survivalism

Finally, it is important to consider what individuating "solutions" may emerge from the conjoined crises of the MMVP and SEP in a collapse scenario. These can likely be divided into three distinct modes of collective individuation that will vie for influence over the future of a post-collapse world. A first would involve the emergence of warlords and war machines/marauding gangs, a kind of "violent survivalism", which would constitute modes of collective individuation that rely on violent expropriation to sustain their individuation capacities. We can see these modes at work in conflict zones and "failed states" across the global south. For example, as John Sullivan shows, criminal networks in many states (e.g. Mexico and Afghanistan) have been increasingly capable of challenging the state's monopoly on force and undermining its sovereignty through "unremitting corruption and cooption of state institutions" (Sullivan, 2011). In some cases these groups may cohere new forms of rule in a kind of quasi-state, as we've seen for example in the rise of the Islamic State straddling ungoverned territories in Iraq and Syria, which could constitute a new and terrible form of molar repression the fills the void left by collapsing Westphalian states. Many nation-states may also devolve into a form of “regional warlordism” where local warlords fight for control key resources and weapons (Urry, 2008: 268-269; Klare, 2004), which may be backed by “war machines” crafted to tax, terrorize, and subdue local populations (Mbembe, 2003: 34). While these examples focus on the global south, we should not discount the possibility that they could emerge in the global north over the course of the 21st century, which could involve groups of ex-soldiers, former cops, private sector mercenaries, rightwing militias, and other far-right groups.[181]

A second solution would involve the emergence of what we could call “neo-feudal bunkers” following a strategy of “exterminism”, in which militarized enclaves aim to secure elite livelihoods and defend them from hungry and desperate communities on the outside. Many analysts across the political spectrum, from Marxists to military strategists and analysts for the World Economic Forum, anticipate that militarized bunkers will become increasingly common as climate change intensifies (Davis, 2010; Schwartz & Randall, 2003; World Economic Forum, 2016). As discussed in chapter two, bunkers have emerged in growing recognition of accelerating crisis conditions, offering essential life-support services to elites capable of affording them and thus enabling them to extricate themselves from the public sphere (Duffield, 2011: 21). More radically

[181] Such risks in the global north may be most acute in the US, where the prevalence of guns, rightwing militias, an ethos of militant survivalism, and agglomerations of molecular fascism raise the frightening prospect of new forms of sub-molar repression emerging as state capacities weaken (Neiwert, 2017; Watson, 2005). Similarly, given that the rightwing British National Party in the UK has taken a keen interest in peak oil, potentially to put themselves in position to assume power and administer a racially pure state should the global economy collapse, such a possibility should also not be discounted in the UK, and comparable developments in other European states should similarly give us pause (Copsey, 2008).

isolated bunkers for the rich are also being constructed, including underground fortified compounds equipped with stores of food and water, medical supplies, billiards, and other forms of entertainment to keep its occupants busy while the world burns outside (Osnos, 2017). These elite movements effectively aim to institutionalize a form of "exterminism", defined by Stan Goff as

> the tacit or open acceptance of the necessity for mass exterminations or die-offs…as the price for continued accumulation and the political dominance of a ruling class…frequently accomplished by calculated neglect (quoted in Angus, 2016: 180).

In the short to mid term, as Mark Duffield describes, such an exterminist scenario, the likes of which we are already experiencing, could involve global cities and elite regions forging "special arrangements, modes of privileged interconnection and private provision in a world where ecological services are becoming scare and increasingly seen as a central to national security" (Duffield, 2011: 24). Even the Davos elite from the World Economic Forum (somewhat ominously) anticipate such a scenario (occurring by 2030!) as described in their 2016 Global risks report:

> The world divides into islands of order in a sea of disorder. As large numbers of people are displaced by environmental change and social violence, still-functioning states seek to protect themselves, often deploying private military and intelligence apparatus to minimize risks of involvement in protracted conflict. In this scenario, by 2030 the world resembles medieval times, when the citizens of thriving cities built walls around them to protect themselves from the lawless chaos outside (World Economic Forum, 2016: 31).

It is plausible that such a neo-medieval world order could persist for a time, especially if effective substitutes for oil are scaled up and climate change progresses slowly. However, further thresholds of collapse that bring down the molar apparatuses of northern states would force exterminist-minded elites to bunker themselves in ever more isolated enclaves, perhaps hiring private security firms to provide protection in exchange for livelihood provisions.[182] This is especially the case in large states like the US and China that require a large continuous influx of material, financial, and human resources to sustain their political-economic and bureaucratic complexity (Tainter, 1988); should these flows be disrupted beyond a certain threshold, then these nation-states will begin to fragment into regional, urban, and various local components. In this way we could begin to see an even more fragmented neo-medievalism in which political-economic elites who are able to hoard critical resources can secure themselves (at least for a time) amidst a growing tide of instability while offering patronage to those willing and able to provide labor, security, entertainment, or other services (Urry, 2008). Certain cities may also remain resilient, particularly medium size cities that are able to provision themselves sustainably via localized food-energy-water assemblages (Greer, 2009). But in a context of severe climate disruption, water and food crises, and raw material and energy shortages caused by a combination of depletion and supply-chain failures, urban and rural/suburban assemblages will be severely challenged to sustain their political-economic complexity and population levels.

Finally, the third likely region of the solution-space in a post-collapse world would involve new forms of "cooperative survivalism", which would likely take the form of egalitarian communities and networks of mutual aid that hearken back to the days of what Marx (perhaps somewhat romantically) called "primitive communism" (Harman, 1999). The making of such modes of collective individuation can already be witnessed in the spread of eco-villages around the world (Birnbaum, 2014), solidarity economies, and

[182] The futurist and technology consultant Douglas Rushkof reports that ultra-wealthy individuals are already coming to him with questions like: "Which region will be less impacted by the coming climate crisis: New Zealand or Alaska? How do I maintain authority over my security force after the event? How would they pay the guards once money was worthless? What would stop the guards from choosing their own leader?" (Rushkof, 2018).

other self-provisioning communities that often emerge in response to economic crises and the failure of the neoliberal state. For example, many anarchist solidarity movements have arisen in Greece in the wake of its decimation by austerity policies, seen in “self-managing social centers” that provide food, shelter, and entertainment for those in need, including refugees (Kitsantonis, 2017). The 1998-2002 economic crisis in Argentina provoked the self-organization of many communal groups to organize collective labor and meet basic needs through horizontal networks, neighborhood assemblies, informal economic arrangements, and worker-managed factories (Sitrin, 2012). Similar movements have emerged in Columbia, where indigenous groups, Afro-descendents, and peasants have sought new forms of social reproduction in the face of extractivist accumulation, financialized housing, and unending drug war (Quiroga Diaz, 2015). The Kurdish resistance movement known as the Rojava that has so far succeeded in occupying regions in northern Syria, which draws inspiration from Murray Bookchin’s libertarian municipalism, can similarly be seen as a cooperative and feminist mode of collective individuation looking to sustain and defend a space of equality amidst a desert sea of chaos, which must simultaneously devise solutions to a harsh local SEP as well as an uncompromising MMVP (Knapp et al, 2016).

These cooperative movements aiming to sustain spaces of solidarity and compassion will undoubtedly face extraordinary challenges to their livelihoods, their well-being, and their values, with the sea of chaos that is likely to surround them forming a powerful attractor that may persistently pull them back towards the violence they hope to escape. Just as international anarchy has historically made democracies rare, since it created pressures for war mobilization that tended to centralize power and create hierarchical warrior cultures at the expense alternative ways of life (Deudney, 2007), so might the advent of a generalized domestic/international "anarchy" in most regions of the planet challenge the values of resilient communities looking to sustain cooperative, egalitarian, and non-militaristic ways of life. It is also possible, however, that such movements, at least in certain cities and regions that are relatively resilient in the face of converging socioecological crises, could gradually become dominant and form a powerful regional attractor capable of pacifying violent survivalists and counter-balancing neo-feudal bunkers, thereby laying the foundations for more peaceful regional (and perhaps even world) orders that could emerge from the ashes of global capitalist civilization. Their individuation capacities and population levels would likely remain permanently constrained, given their advent into an SEP structured by critical resource scarcities and likely runaway climate change. Yet they may nonetheless form spaces of compassion and care that would "constitute critical seeds of resilience necessary for navigating and surviving" the challenges of a post-collapse world (Kuecker & Hall, 2011: 21) while also perpetuating the possibility of a "life worth living" (Stiegler, 2013).

Conclusion

To summarize, the SEP is structured by intersecting crises in the earth system, global economy, food and energy assemblages, and cognitive-affective assemblages, which most often interact through positive feedbacks, though sometimes through negative feedbacks. These crises will inevitably force a bifurcation beyond neoliberal hegemony, either in the form of a near-term transition to a Green Neo-Keynesian regime or a spatiotemporally uneven collapse (which could happen relatively soon in the case of energy-financial-food shocks, or more long-term in the case of runaway climate change and resulting food-financial shocks and critical infrastructure failure). The Green Neo-Keynesian regime will itself only be sustainable if FIR technological breakthroughs enable economic growth to rapidly decouple from GHG emissions and stress on other planetary boundaries (especially biodiversity and land-use change); otherwise it will likely be little more than a temporary way-station on the road to either ecosocialism or collapse. Even if the Green Neo-Keynesian solution to the SEP could be made sustainable through FIR breakthroughs, it would then rely on the diffusion of technologies that intensify the MMVP to the point of a catastrophic world-assemblage bifurcation, likely in the form of a Planetary Techno-Leviathan. In contrast, a low-throughput ecosocialist world-assemblage would likely be the ideal resolution of the Planetary Problematic as a whole, which would (at least in principle) be capable of securing the conditions of possibility for diverse vectors of collective individuation in the mid and long term. A world-assemblage collapse scenario, on the other hand, which may very well be the most likely outcome according to present trajectories, would unleash extraordinarily difficult challenges for disparate modes of collective individuation across the globe, though we must face these challenges and their implications head on in order to map the problem and solution space for communities hoping to successfully navigate the challenges, opportunities, and constraints it would present.

While the foregoing scenarios are undoubtedly speculative, they are grounded in a systematic multi-dimensional analysis of political-economic, ecological, technological, and cognitive-affective trends. These scenarios are also to some extent “ideal types”, whereas the actual planetary assemblage in the coming decades is likely to involve (and already involves) complex and uneven mixtures of the three at different scales (Frase, 2016). For example, "collapse" is already a reality for much of the world-assemblage today, not only in the conflict-stricken and climate-stressed states of the global south but also in inner-city neighborhoods throughout the global north. And in the future it is possible to envision state failure across much of the world-assemblage even as the latter stabilizes in a Green Neo-Keynesian attractor, or to envision authoritarian Green Neo-Keynesian states in the global north securing themselves through emergency governance, rationing, and fortified borders as the world-assemblage undergoes an uneven collapse. It is likely, however, that one of these solutions would form the dominant attractor at the world-assemblage scale in the sense that it would reorganize most if not all states and regions according to its structure and feedbacks. For example, it is unlikely that even heavily securitized Green Neo-Keynesian states in the global north would be able to remain stable throughout the duration of a world-assemblage collapse (since they would lose critical flows of matter-energy and finance while facing a heavy barrage of molecular violence from human and non-human forces). Christian Parenti effectively makes the point: "If climate change is allowed to destroy whole economies and nations, no amount of walls, guns, barbed wire, armed aerial drones, or permanently deployed mercenaries will be able to save one half of the planet from the other" (Parenti, 2011: 11). Thus while we are likely to see one of the three attractors eventually take hold at the global scale, it will likely take at least two to three decades, likely longer, for the world-assemblage to settle deeply into a new attractor. Before then the world-assemblage will likely fluctuate in the "zone of sensitivity" between attractors (Protevi, 2009: 6) – with tendencies towards Green Neo-Keynesianism, Ecosocialism, and Collapse pushing and pulling the world-assemblage in contradictory directions before settling into a new configuration of mutually reinforcing feedbacks.

Given the complexity of the Planetary Problematic and solution-space, the need for a "methodology" that combines quantitative and qualitative analysis with synthetic intuition and "imaginative rationality" (Mickey, 2014: 30) should hopefully by now be clear. Echoing Nafeez Ahmed, it can be said that none of the scenarios and trajectories described here "was ever modeled or predicted by any scientist" reliant on quantitative modeling, since

> a full and accurate model of the scope for human agency's input into various crisis-trajectories would require a vast amount of historical, sociological, geopolitical, economic and cultural data, most of which could never be quantified (Ahmed, 2017: 93).

As emphasized earlier, this is by no means meant to deny the value of such models, but merely to indicate that they are clearly limited in their capacity to understand the multi-dimensional qualitative complexity of the Planetary Problematic and anticipate its messy possible trajectories, which will inevitably be determined by the strategies of states, political-economic elites, and counter-hegemonic movements as much as by the geophysics of climate, energy, and food systems. Only approaches that combine a rigorous assessment of quantitative studies alongside a theoretically disciplined exercise of synthetic intuition, imagination, and narrative, thereby actualizing the "intelligence of complexity" (Morin, 2006), can begin to comprehend this problematic and its solution-space. Many social scientists and futurists have done excellent work probing this possibility space, perhaps Nafeez Ahmed most of all (Ahmed, 2017), but also world-system scholars like Christopher Chase-Dunn and Kirk Lawrence (Chase-Dunn & Lawrence, 2011); sociologists like John Urry (Urry, 2011, 2016); IR scholars like Heikki

Patomakki, Tim Di Muzio, Thomas Homer-Dixon, and Jairus Victor Grove (Patomakki, 2006; Homer-Dixon, 2006; Di Muzio, 2015; Grove, 2019); Marxists like William Robinson, Geoff Mann, and Joel Wainwright (Robinson, 2014; Mann & Wainwright, 2018); and various futurists like Jonathan Porritt, John Michael Greer, Paul Raskin, and others (Porritt, 2013; Greer, 2008, 2009; Raskin, 2016). The Deleuzian "minor scientific mapping" approach formulated here can be read as a theoretical elaboration of what many of these scholars have already been doing, and it hopes to contribute an ontology and "methodology" that can help bring greater clarity, rigor, and multi-dimensional synthesis to the urgent task of mapping our 21st century predicament, while informing counter-hegemonic responses at multiple scales.

Conclusion

In 2008, in the wake of a financial crisis that had brought global capitalism to the brink of collapse, a perplexed Queen Elizabeth posed a question that had flummoxed the minds of many of the world's "best and brightest" economists: "why did no one foresee the timing, extent and severity of the Global Financial Crisis?" A year later a group of academics from the British Academy replied that this was the result of "a failure of the collective imagination of many bright people…to understand the risks to the system as a whole" (Besley et al, 2009: 3). Their letter further specified that "risk calculations were most often confined to slices of financial activity, using some of the best mathematical minds in our country and abroad. But they frequently lost sight of the big picture" (ibid: 1). In other words, while there were of course many who did anticipate the crisis, there was a widespread failure to connect the dots between the multiple sources of accumulating systemic risk, a result of both the isolationist tendencies of economics and the willful blindness of those hoping to indefinitely maintain their continuationist dance to the rhythm of business-as-usual.

Twelve years later, in 2020, we find ourselves engulfed in another "predictable surprise" (Spratt & Dunlop, 2017: 38) that has shattered the rhythm of business-as-usual and may turn out to be the worst crisis in capitalism's history (Smith, 2020; Ghosh et al, 2020). Many had warned that the conditions for a devastating pandemic had been building for decades – including unrestrained intrusion into formerly intact ecosystems, thereby bringing humans into ever closer contact with zoonotic disease vectors; an economy of just-in-time supply chains and trade linkages that promote "efficiency" (economic rather than ecological) over resilience; and insufficient healthcare capacities even in the so-called advanced economies weakened by decades of neoliberal austerity; among other factors (Qualmen, 2012; Garrett, 2011). Yet it was difficult for most policy-makers, academics, and the wider public to appreciate both on an intellectual and *especially* affective level that we would sooner or later confront disaster – and perhaps much sooner than anyone anticipated.

While its intellectual edifice had already been crumbling (despite the efforts of ecomodernists and new optimists), what we could call the "continuationist consensus" – which includes the intellectual view that global capitalism and its rhythm of progress-understood-as-economic-growth can continue indefinitely, as well as the shared "structure of feeling" that it *will* continue – is today on life-support. Though it has not yet reached the level of "common sense" (in the Gramscian sense), the view that our business-as-usual world is ending, that we're poised on the threshold of a new era of political-economic and ecological turbulence, has rapidly ascended from "fringe opinion" to a truism for many (Scranton, 2020). Indeed, while it has become an increasing truism for many scientists – particularly since the 2018 IPCC report's call for "rapid and far-reaching" transformations that are "unprecedented in terms of scale" (IPCC, 2018: 21) – the Covid-19 pandemic has forcibly brought the unsustainability of our present trajectory into the realm of collective affect. In this way, as Kim Stanley Robinson writes, the pandemic may be catalyzing the emergence of a new cognitive-affective attractor (or what he calls, following Raymond Williams, a "structure of feeling"):

> In our feelings, we've been lagging behind the times in which we live…we've been acting as though it were 2000, or 1990—as though the neoliberal arrangements built back then still made sense. We've been paralyzed, living in the world without feeling it….We [didn't] want to change our habits…[yet] the virus is rewriting our imaginations. What felt impossible has become thinkable. We're getting a different sense of our place in history. We know we're entering a new world, a new era. We seem to be learning our way into a new structure of feeling (Robinson, 2020).

Of course, we do not yet know what the longer-term political-economic and cognitive-affective implications of the Covid-19 pandemic will be. This will depend on how long the crisis lasts (itself contingent on progress on developing a vaccine and treatment options, as well as mutations in the virus) and the severity of the subsequent shocks in geopolitics, energy, food, finance and the global economy. But we know that the pandemic has struck the capitalist world-system at a moment of pre-existing weakness, including high levels of private, corporate, and public debt and historically low interest rates to maintain "normal" growth rates; increasing reliance on lower EROI oil reserves and corresponding vulnerability of unconventional producers (who rely on high prices to stay profitable) to demand shocks; climactic stresses on food systems across the globe (including intense drought and record yield declines in Australia, drenched fields across the US Midwest leading to the lowest wheat plantings in a century, and an unprecedented locust outbreak across the Middle East and East Africa that threatens the food supply of 20 million people[183]); a fragile multilateral world order marked by trade tensions, neo-nativist resurgence, weakening arms control, and demagogic leaders across the international system; and an ongoing legitimacy crisis of neoliberal capitalism. Therefore, the chances are high that the pandemic will accelerate the world-system's passage towards catastrophic bifurcation,[184] and the project of thinking beyond continuationism has become more pressing than ever.

This dissertation has been a contribution to the project of thinking beyond both isolationist analysis – which constrains the study of global crises in the natural and social sciences – and the continuationist consensus that continues to constrain the imaginations of social scientists, policy-makers and the wider public (even as it slowly crumbles). It has done this by developing a multi-dimensional and synthetic form of global systems analysis – Planetary Assemblage Theory – that can deepen our understanding of *why* the world-system is on the cusp of a catastrophic bifurcation and of *how* it may unfold down multiple possible trajectories towards alternative attractors. It builds on isolationist

[183] See Berwyn, 2020; Prakash & Srivastava, 2020.

[184] For example, the pandemic is sparking widespread conversations about the need for a "green" recovery, thereby increasing the near-term chances of at least a moderate Green New Deal (especially in Europe, and possibly the US depending on the outcome of the 2020 presidential election). More radically, it may be increasing the likelihood of a post-growth ecosocialist transition in the mid term by reviving practices of mutual aid and violently shaking populations out of their consumerist slumber, forcing them to slow down and reflect on what is most important. Especially if the crisis lasts for 2-3 years, as some experts anticipate, will people shift back readily into the consumerist cognitive-affective attractor, or will widespread cognitive-affective transitions materialize? On the other hand, the roll-out of digital contact tracing apps to intensify bio-surveillance may be difficult to reverse as the pandemic wanes, thereby accelerating the transition towards techno-authoritarianism (as we're already seeing in China and South Korea). Finally, efforts to restore "growth at all costs" (green or otherwise) in the wake of the pandemic, which would be likely in the US if Trump is re-elected, would reinforce and may accelerate the trajectory towards collapse. Particularly if current spikes in deficit spending are followed by another round of austerity, this would both slow down the renewable energy transition and strengthen the forces of neo-nativist and quasi-fascist backlash. In this case, our trajectory towards global collapse would be sealed.

analyses across the domains of political-economy, climate science, food and energy system analysis, and the study of catastrophic technological risks, along with the pioneering efforts of transdisciplinary scholars and initiatives to understand the feedbacks between these systems and anticipate their possible futures – including the work of Ecological Marxists, World-System Theorists, earth system scientists, resilience theorists, and integrative global system analysts like Nafeez Ahmed and Thomas Homer-Dixon. In doing this it aims to build bridges between the "two cultures" of the sciences and humanities, in particular between the traditions (broadly understood) of apolitical complex systems thinking and modeling on one hand (e.g. the limits to growth, social-ecological systems theory, and Integrated Assessment Modeling efforts) and critical theory on the other (particularly but not solely the traditions of Marxist, Deleuzian, and Foucauldian analysis). Overall, I hope that Planetary Assemblage Theory, its map of the planetary crisis convergence and its possible futures, can be a useful tool in the service of communities, social movements, and policy makers trying to grapple with where our world may be headed and how we may best respond.

This conclusion will proceed by tying together and expanding on some of the main conclusions and implications of the analysis developed throughout the dissertation. I will first elaborate on the possible futures of the world-assemblage, providing a more nuanced set of possible scenarios that builds on the analysis in chapter six, before clarifying the methodological means and motivation of this futures analysis. I will then discuss some of the possible implications for political strategy and praxis that may emerge from these conclusions. Next, I will briefly discuss the geographically uneven and combined nature of both the Planetary Problematic and solution-space, which received insufficient attention in chapter six and must be further elaborated in future work. Finally, I will conclude with some reflections on the productive tension between hope and pessimism in responding (intellectually, emotionally, and practically) to our planetary predicament.

Nine Possible Futures and the Ends of Futures Thinking

As noted at the end of chapter six, the three broad possible futures for the world-assemblage that I describe – Planetary Techno-Leviathan, Ecosocialism, and Collapse – can be considered "ideal types" that could emerge and unfold in different ways (with better or worse implications for human and multi-species flourishing). The scenarios described in chapter six will therefore strike many as being overly simplified and missing many of the complex, messy, and uneven characteristics that any actual future will bring. Such impressions would be wholly warranted, and while simplification is to some extent unavoidable we can also go further by specifying sub-types within each ideal type scenario. These sub-types can be distinguished according to timing (e.g. whether they emerge before or after mid century), whether or not they stabilize average global temperatures at 1.5-2°C or not, and whether they take more democratic or authoritarian forms. Without claiming to exhaust the range of variation, I will nonetheless show that we can bring more specificity to our future possibility space by nuancing the description of the three main ideal type future along these lines. Overall, I will suggest that we can identify *nine possible futures* for the world-assemblage. Of course, many more are undoubtedly possible, and I do not claim to possess a crystal ball. In the end, as Roy Scranton writes:

> the future we face is utterly unprecedented, an impenetrable obscurity, a vast and dismal cloud of unknowing…we cannot know how climate change and ecological catastrophe are going to transform our world, how human civilization will change in response…or who we will become in the future (Scranton, 2020).

Indeed, while recognizing the futility of really trying to *know* the future, as well as the arguably hubristic and possibly downright silly attempt to anticipate all possible trajectories of the planetary assemblage, I believe we can usefully create a rough possibility space – using the best available knowledge that we can reasonably integrate as cognitively constrained human beings – that will undoubtedly capture some important things and miss others. What follows is my best effort thus far in this task.

Planetary Techno-Leviathan

Scenario 1: a near-term Green New Deal (i.e. emerging in the 2020s) followed by technological breakthroughs catalyzed by the "Fourth Industrial Revolution" (FIR) enables rapid decoupling of economic growth from emissions (plus scaled up Net Emissions Technologies) to stabilize average global temperatures at 2°C. However, FIR technologies and the resulting democratization of WMD capacities unleash a spiral of insecurity and securitization that pushes the world-assemblage away from the hegemony of economic growth towards security as the over-arching systemic principle, thereby empowering a Planetary Techno-Leviathan (PTL) to survey and police populations across the planet. What emerges then is an ambiguously "post-capitalist" world-assemblage in which the majority of citizens reproduce themselves through Universal Basic Income rather than wage labor; where technology corporations like Google and Facebook have become appendages of state security assemblages (rather than private enterprises focused on profit maximization); and where rights to privacy, mobility, and public assembly are significantly restricted (though more-or-less draconian scenarios are possible). Extractivist "sacrifice zones" would increase threefold or more[185] from current levels to deliver the raw materials needed for the "green energy" transition, while most if not all the world's remaining peasantries would be dispossessed and forced into the informal economies of mega-cities across the global north and south. Inequality would remain rampant, and regions like Sub-Saharan Africa and the Middle East – which would be hit hardest by a 2°C increase – would continue to experience chronic conflict and food-water insecurity (even as technology transfers and humanitarian aid, provided by leading states in the interests of fighting non-state terrorism, prevent mass mortality). Earth would be significantly degraded, but ultra-dense mega-cities across the world-assemblage and breakthroughs in next generation nuclear reactors, renewable energy, desalination technology, vertical farms and synthetic food would enable it to support a population of 8 to 9 billion.

Scenario 2: In this version a GND effort to rapidly reduce emissions occurs too late, and the Paris Agreement targets are exceeded as a result. However, a combination of FIR-enabled breakthroughs, slow feedbacks in the climate system, and sustained global cooperation enables the emergence of a new world order capable of governing geoengineering, relocating much of the world population to more habitable regions, and transforming and relocating agriculture, thereby enabling the majority of states and the

[185] This follows De Konig et al's projection of a rise in metal extraction by a factor of 3-4.5 to meet the material needs of a future renewable energy system, which may be conservative (though it may also be reduced by dramatically increased rates of recycling) (De Konig et al, 2018).

global economy as a whole to muddle through. Gaia Vince provides a compelling description of what this might involve, which would require

> cooperating as never before to radically reorganise our world: decoupling the political map from geography…It would mean abandoning huge tracts of the globe and moving Earth's human population to the high latitudes: Canada, Siberia, Scandinavia, parts of Greenland, Patagonia, Tasmania, New Zealand and perhaps newly ice-free parts of the western Antarctic coast…These precious lands, with tolerable temperatures and access to water, would also be valuable food-growing areas, as well as the last oases for many species, so people would need to be housed in compact, efficient high-rise cities with reflective roofs and resource-recycling systems… Food production will need to be more intensive, efficient and industrial. This will be a mostly vegetarian world, largely devoid of fish and without the grazing area or resources for livestock (Vince, 2019).

The spiral of insecurity and securitization would be even worse than in previous scenario due to insecurity from 3 or 4 °C of climate change this century (combined with the democratization of WMD capacities), thereby catalyzing the creation of a PTL to securitize the planet while rationing its remaining resources (mainly to support the reproduction of certain forms of life and populations at the expense of others). The climactic devastation of much of Africa, the Middle East, Southeast Asia, central and South America, combined with the extractivist drive for "green growth" in the world-assemblage core, would create an intensive "climate apartheid" buttressed by militarized borders, drone swarms policing restive populations, and algorithmic surveillance coupled with automated force projection to detect and punish anomalous behavior (Pasquineli, 2015). Earth would be devastated and inequality would reach unparalleled heights, though ultra-dense cities in the more habitable regions of the global north and FIR breakthroughs may enable the survival of a 7-8 billion population in a brutal and spiritually impoverished world.[186]

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[186] Whether or not 7-8 billion humans could survive in a 4 degree world is highly contested. Many scientists, including Johan Rockström, believe a 4 degree world could only support a population of 4 billion, while others are even more

Ecosocialism

Scenarios 3 and 4: a near-term Green New Deal (GND) is followed by crisis and stagnation, with powerful social movements forcing governments in key states to radicalize in the direction of democratized planning, redistribution, and material-energetic degrowth in the overdeveloped countries of the global north. The Paris Agreement targets are met and a more egalitarian world order emerges based on more simplified and localized political-economies with lower material-energy throughput. However, this may involve at least two further sub-types, including a) *Democratic Ecosocialism,* which would be enabled in part by the proliferation of community led sustainability initiatives and linkages with a strengthened and increasingly coherent labor and environmental justice movement. Together these movements could take advantage of the crisis of the GND by accelerating the process of cultural transformation towards more frugal and community-based economies with lower levels of consumption and more capacities for democratic self-governance; or b) *Authoritarian Ecosocialism,* in which community led relocalization initiatives remain marginal, cultural change is slow, and the proliferation of humanitarian emergencies created by climate impacts and food-water-energy stresses lead to centralized rationing enforced through military and police power. This could involve something like what Mann and Wainwright describe as a technocratic "Climate Mao" that declares "the necessity of a just terror in the interests of the future of the collective" (Mann & Wainwright, 2018: 38). This more authoritarian form would also

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pessimistic (Vince, 2019). More techno-optimist approaches, on the other hand (e.g. Ken Caldeira), believe high population levels could still be supported: "If people are rich enough to air-condition their lives, they can watch whatever is the successor to *Game of Thrones* on TV, as the natural world decays around them" (quoted in Vince, 2019).

be more likely if the proliferation of FIR technologies leads to an insecurity-securitization spiral (e.g. as would occur in ecomodernist visions of "ecosocialism").

Scenario 5: A GND occurs too late and the Paris Agreement targets are exceeded. Widespread realization that a GND is too little too late, combined with global systemic turbulence and strengthening labor and environmental justice movements, enables a series of revolutions and democratic transitions towards ecosocialist principles later this century. Collectively managed geoengineering, global roll-out of net emissions technologies, global agricultural transformation to sequester carbon, slow feedbacks in the climate system, and a massive globally coordinated program to relocate climate refugees from around the world in the more habitable regions of the global north enables the emergence of a more egalitarian and resilient world order that can secure basic needs amidst earth system chaos (between 3 and 4 °C by 2100). This follows something like Holly Jean Buck's scenario of both political-economic transformation *and* geoengineering to stabilize the earth system – "an orchestration so elaborate and requiring so much luck that people may find it a fantastic, utopian dream" (Buck, 2019: 34). Yet this is not a scenario we should discount. As Buck explains:

> We can maximize our chances of muddling through by engaging proactively with both carbon removal and solar geoengineering…geoengineering does not have to substitute for transformation change...These overlapping binaries – geoengineering versus real change, geoengineering versus agroecology – obscure the reality that there is a spectrum of ways of doing, enacting, practicing, deploying, or implementing climate intervention…Sticking rigidly to these binaries keeps us from seeing possible futures (ibid: 39-40).

However, an authoritarian form of ecosocialism, based on the empowerment of a centralized "Climate Mao" to equitably ration the earth's remaining resources (by force if necessary) and govern a global solar geoengineering program, would be more likely in this scenario (Mann & Wainwright, 2018).[187]

Collapse

Scenarios 6 and 7: Near-term energy-financial-food-climate shocks provoke terminal political-economic depression beginning in the 2020s or 2030s. A new world-assemblage equilibrium emerges with significantly reduced levels of consumption, global complexity, governance capacities, and standards of living. This may further result in two different trajectories (likely a combination of the two, though one would eventually become dominant at the global scale): a) *Progressive Adaptation* towards simplified economies, with pockets of more egalitarian communities and other areas resembling something more like neo-feudalism, and other areas stricken by chronic conflict (Friedrichs, 2013). Economic collapse would rapidly bring down emissions, and combined with rewilding and a shift to carbon sequestering agroecology, this might stabilize global temperatures between 1.5 and 2 °C. Population levels would likely diminish due to increasing mortality from climate disasters, food and water insecurity, disease, and conflict – perhaps significantly, but far less catastrophically than in other collapse scenarios; or b) *Auto-Catalytic Collapse Spiral* (or "dissolution trap"[188])*:* Powerful states like the US and China turn to domestic authoritarianism (possibly neo-fascism), predatory militarism and "growth at all costs" strategy, which simply reinforces collapse over time and leads to continuing growth in emissions. The result is a worst-case

[187] This is both because insecurities would be intensified by climate chaos, bolstering calls for emergency governance, and because the states and global institutions responsible for carrying out solar geoengineering would place themselves in a position of immense power: all of humanity would be reliant on them to maintain the program in order to avoid a disastrous "termination shock". In this way, as Mann and Wainwright anticipate, "the state or sovereign that initiated [Solar Radiation Management] would arrogate to itself its own perpetual necessity" (Mann & Wainwright, 2018: 150).
[188] See Fath et al, 2015.

scenario of both near-term political-economic collapse and runaway climate change, leading to mass mortality and possibly human extinction by late 21st or early 22nd century (especially if nuclear war is triggered).

Scenarios 8 and 9: these involve longer-term collapse trajectories (i.e. between 2060 and 2100) in which energy shocks and/or financial crises don't bring down capitalism before mid-century, and a GND either never materializes or comes as too little too late. Instead, continuous compound growth and increasing energy consumption lead to ecological collapse and runaway climate change, which reaches between 4 and 6 °C by the end of the century depending on strength of positive feedbacks. The breakdown of international cooperation and self-serving measures by states lead to conflicts over dwindling resources, migration, and possibly nuclear war. This could also involve a failed effort to govern solar geoengineering, with a combination of technical challenges and inter-state conflict leading to a catastrophic "termination shock" (MacKinnon, 2019); or it could entail the collapse of an ecosocialist transition-in-process due to resistance from capitalist-remnants and reactionary forces. In turn, this may lead to one of two possible trajectories: a) *Pockets of Surviving Communities*, totaling perhaps a few hundred million people (perhaps significantly more or less), in more habitable polar regions of the planet. Some of them take neo-feudal, others more egalitarian forms, though the latter must defend from more aggressive expansionary modes of collective individuation. This scenario is more likely if positive feedbacks remain slow and especially if nuclear war avoided; or b) *Extinction*, either in the late 21st or 22nd century. This would be more likely in the case of strong positive feedbacks in the earth system and especially if political-economic collapse and climate chaos trigger nuclear conflict.

At this moment it may be appropriate to engage in a moment of what Theodor Adorno describes as "clowning", or "talking about things in a way that acts as if they are entirely known…all the whilst knowing how ridiculous [our] claims to knowledge are" (quoted in Mickey, 2014: 25). In short, as admitted above, the claim to anticipate the possible trajectories of the world-assemblage may be reasonably perceived as nothing short of ridiculous. At the end of the day, I have no fucking idea what will happen. Who could have predicted that the trigger precipitating what will likely become the terminal crisis of neoliberalism, having been anticipated by many, would take the form of a coronavirus pandemic? I certainly did not anticipate this. Furthermore, for all I know we will *actually* get limitless fusion energy in 30 years time, or a Superintelligent AI Singleton that solves our sustainability crises for us, or a Yellowstone Supervolcano explosion that destroys the continental US and upends world order, or a giant solar flare that brings down electricity grids and collapses the world economy into semi-permanent darkness, or (perhaps most poetically) a collapse in the vacuum energy of our cosmic neighborhood that eviscerates the sub-atomic foundations of earth, humanity, and all chemistry. A bit of humility is therefore in order. Nonetheless, I do not believe we need to, or should, simply accept our absolute unknowing, embrace the formless void of the future, and relinquish all efforts towards anticipation, as some like Roy Scranton call for (Scranton, 2020). Instead we can use the best available knowledge – involving both quantitative projections of climate-economic-food-energy system processes and qualitative understanding of political-economic patterns, relations of power, and possible thresholds in the world assemblage – to make reasonable projections and construct a range of plausible scenarios. As emphasized by the IPCC and others engaged in anticipating global socio-ecological futures, the goal is not to predict what *will* happen but rather to explore what *could* happen under a range of different “what if?” scenarios, which can be understood as “comprehensive, plausible, integrated descriptions of possible futures based on specified, internally consistent underlying assumptions” (IPCC, 2018: 98). However, as previously discussed, such futurological exercises must be continuously updated and revised as events in the world unfold and new information comes to light. The Covid-19 pandemic is certainly one such event that will ultimately shape the course of the planetary crisis convergence and require a re-assessment of its possible trajectories and their timelines.

We should however address one question that has so far received minimal attention in this dissertation, since the answer will not be obvious to all: Why try to anticipate futures at all? What purpose does this serve? In my view, the purpose of futures thinking is not to develop detached predictions, as though “the future” were already actualized and amenable to objectivist analysis. In short, the future is not a “spectator sport” (Lent, 2019b), but rather a virtual field of struggle that requires a praxis of “imaginative rationality” and experimentation to contribute to the actualization of more just and sustainable futures (Mickey, 2014: 30). Following William Connolly, it involves the work of a “seer”, one who “sees how crucial shifts in the pace of events and the timing of responses are to the world” and strives to “fabulate a potentiality on the verge of activation”, thereby participating in its becoming (Connolly, 2011: 153, 162). As Sam Mickey describes, futures thinking in this sense “does not entail simply reflecting on plausible scenarios or thinking about events that can or could happen. It entails creating new fields of what is possible, exceeding the coordinates of probabilities" (ibid). This resonates with Deleuze's concept of "counter-actualization", explained by John Protevi as a praxis of "changing the virtual conditions for future actualization" (Protevi, 2013: 151). In fact, it is arguably best to read Marx and Engel's "prediction" that communism would replace capitalism in this way: not an objectivist prediction but rather a strategic praxis of counter-actualization aiming to inspire affects, imagination, and activism to bring new worlds into existence.

In this sense, futures thinking can be a means to catalyze imagination of progressive futures; to make dystopian futures more affectively vivid and thus inspire activism and policy in the present to ward them off; or to develop strategic foresight among social movements, communities, and governments, thereby aiding their efforts to develop "strategies, designs or plans that perform well under a range of future conditions" and that can take advantage of the opportunities afforded by future crises (Maier et al, 2016: 155). Foucauldian theorists have effectively demonstrated how security planners and financial actors use futurological exercises like scenario planning in this way to "sustain a desired state in the face of any possible and unexpected disruption" (Aradau, 2010: 6; see also Cooper, 2010; Anderson, 2010). For example, central banks, financial supervisors, and heterodox economists are increasingly turning to "forward-looking, scenario-based methodologies" to deal with the "deep uncertainty" posed by climate change and its possible impacts on economic growth, financial stability, and geopolitics, since climate-economic models "are inherently incapable of representing all these interactions" (Bolton et al, 2020: 21-23). Melinda Cooper may exaggerate when calling futures thinking "the most ubiquitous and most consequential of epistemologies in contemporary politics" (Cooper, 2010: 171), though it is certainly becoming an increasingly influential technique for developing robust future-oriented strategies in conditions of deep uncertainty (Maier et al, 2016). However, none of these thinkers reflect on how social movements and communities can use (and already are using) similar techniques to prepare for future crises, envision more desirable futures, and develop strategies to bring them about (Hopkins, 2008; Penha-Lopes et al, 2019). In an era of crisis, where we sit on the threshold of a chaotic phase transition that will mark the passage into new worlds, such exercises in futurological imagination and praxis are more crucial than ever. Rather than allowing states, military planners, and financial institutions to monopolize these techniques in their efforts to preempt and constrain the future possibility space, we should instead be developing creative transdisciplinary efforts – bringing together natural and social scientists, activists, progressive policy-makers, writers and story-tellers from diverse race, class, gender, and geographic perspectives – to envision better futures that are emboldened by imagination and disciplined by theoretical and quantitative rigor.[189] Developing collective imaginaries and strategies across different movements on how to actualize these futures, both through prefigurative activism in the present and long-term organizing and strategic planning, is the more difficult though no less important challenge.

Implications for Praxis

It is worth briefly discussing how the exercise in futures thinking developed here may concretely inform social movement strategy and experimentation towards developing counter-hegemonic alternatives. Broadly speaking, this analysis can help us

[189] Paul Raskin's "Great Transition Initiative" is an exemplary project in this respect (Raskin, 2016).

understand the structural constraints and opportunities for counter-hegemonic agencies to reshape the world-assemblage, while also identifying non-desirable attractors that should be avoided and suggesting ways we can navigate away from them towards more desirable attractors. As Marxists like David Harvey remind us, there are always multiple options in a time of crisis, though the possibilities aren't infinite: "it is the task of analysis to uncover what might now be possible given the current state of class relations throughout the world" (Harvey, 2010: 71). Of course, beyond the current state of class relations, we must also include an analysis of the climate-food-energy-technological conjuncture and the constraints it imposes and opportunities it affords.

Starting with the Green New Deal, this dissertation follows Ecological Marxists, ecological economists, and energy analysts who show that the GND – so far as it remains within a capitalist growth-based framework – will be insufficient to address both the climate and broader earth system crisis (Cox, 2020; Kallis & Hickel, 2019; Parrique et al, 2019) (barring exponential technological breakthroughs, in which case the Planetary Techno-Leviathan awaits). However, it goes a step further by showing that while something like a GND is almost certainly necessary as a transitional stage towards a more genuinely sustainable political economy (since the conditions for an ecosocialist transition in key nodes of the world-assemblage are not yet ripe), it would be unsustainable and most likely bifurcate towards either ecosocialism, collapse, or techno-authoritarianism depending on the progress of technology and shifting balance of class and social forces. In short, the GND is a necessary though contradictory agenda, since it promises to simultaneously promote economic growth and environmental protection, to simultaneously boost wages and worker rights while restoring profitability for manufacturing, and to rapidly reduce emissions without generating a debilitating carbon bubble shock. The feminist economist Julie Nelson usefully (though partially) articulates the nature of this bind:

> The Green New Deal proposals…*are* pulling a bit of a bait-and-switch when they talk about 'high wage jobs' and 'prosperity.' Politically speaking, this rhetoric is probably necessary – no one is going to propose legislation promising reduced employment and poverty. Realistically, though, what 'prosperity' means while living sustainably in a resource-constrained world will necessarily be different from how many define it today (Nelson & Morgan, 2020: 150).

In other words, Green New Dealers are in the awkward position of needing to "over-promise" in order to garner widespread support among populations, and thus they may be setting them up for disappointment. Naomi Klein's faith that the GND would be a "backlash buster" may in this sense be misplaced (or at best one-sided) (Klein, 2019: 287). Therefore, while we must fight to actualize a GND in key states as soon as possible, we must simultaneously prepare for the GND to destabilize and strategize how to push the bifurcation towards more radical ecosocialist principles (rather than collapse or techno-authoritarianism). In the near term, this requires thinking carefully about the rhetoric and narrative strategy surrounding the GND – how do we balance between the competing dictates of bolstering public support for the GND while also being more forthright about the sacrifices it would entail (i.e. not promising the moon and more)? The next challenge would then be to win the narrative battle during the eventual crisis of the GND: how do we defeat the reactionary narratives that will blame environmentalists for their economy-killing strategies and aim to restore "growth at all costs" by promoting the narrative that the solution is to end reliance on growth once and for all and create a more equitable post-growth economy?

Furthermore, given the dangers of the GND evolving down the road towards Planetary Techno-Leviathan (if the "technological miracle" indeed manifests), activists and social movements should strategize to preempt these dangers. This will be a major challenge, especially since efforts to pass a GND in the US may require an unholy alliance with the primary agents of "surveillance capitalism" (Zuboff, 2019) – Silicon Valley and "Big Tech" – since they are the most powerful players within the "green capitalist" faction of the capitalist class. Albert Pinto and Anusar Farooqui claim that forging such an alliance is "a price that the left must be prepared to pay because of the urgency of the planetary impasse" (Pinto & Farooqui, 2019). Indeed, given the relative weakness of the democratic socialist left and immense cultural and political obstacles in the way of a genuinely progressive GND in the US, they may be right. But the question then becomes how, if such a GND coalition is necessary, to prevent this from morphing into a PTL. The struggle to break up these tech monopolies and assert public control over data takes on an increased salience, and activists and social movements should fight against concessions to Big Tech that would enable them to retain private control over the informational fabric of our societies in exchange for their support for a GND. A further and related struggle would be to enhance democratic control over the pace and direction of technological innovation, thereby counter-balancing the influence of the Silicon Valley digital elite in determining our technological future. In contrast, "peoples' assemblies" should be empowered to debate the relative benefits and risks posed by emerging technologies (from synthetic biology to the internet of things, nanotechnology, neurotechnology, and AI) and set mandates regarding investment levels and priorities, the direction of research, and the pace of deployment, while also having the right to "relinquish" certain technological trajectories if their risks are perceived to outweigh the benefits.

However, if a combination of intensified surveillance capitalism within a GND regime plus a FIR-driven insecurity-securitization spiral forces the world-assemblage towards a techno-authoritarian attractor, then this is not simply the end of the story. Rather than bowing down to the PTL, the terrain of struggle would then shift towards fighting to actualize one with as much democratic oversight and accountability as possible, with surveillance running in all directions. While such a regime would pulverize privacy rights and constrain human mobility, it may be possible (though difficult) to mobilize to protect individual freedoms of speech, peaceful protest, and assembly. In short, more and less totalitarian (and terrifying) forms of the PTL are possible. If we are unable to collectively resist the techno-authoritarian attractor, then social movements will need to rise to the challenge of constraining and taming the powers of the PTL as much as possible.

Finally, it is necessary to prepare strategically for the possibility of global political-economic and ecological collapse. Many thinkers and activists are coming to the conclusion that a global collapse is inevitable (e.g. Bendell, 2018; Grove, 2019), though such conclusions are intensely resisted by others emphasizing the window of opportunity available for radical transformation (Lent, 2019a). I will return to this issue below, but for now I will simply note that a time may come (if it hasn't already) when the collapse attractor becomes inevitable, at which point social movement strategy and experimentation should be retooled to prioritize collapse preparation and harm reduction. In other words, rather than the "revolution or bust" strategy adopted by many Green New

Dealers and Ecological Marxists (e.g. Foster et al, 2011; Angus, 2016; Klein, 2019; Magdoff & Williams, 2017), more careful thinking about the variegated threats, constraints, and opportunities that may be afforded to diverse communities and regions during a world-assemblage collapse must be considered. We must recognize that, for all the suffering and death that would emerge over the course of a collapse trajectory, it would continue to pose multi-dimensional problematics with definable and actualizable solution-spaces to those who are sufficiently fortunate and well-positioned. New ways of life could and would emerge in the wake of this world's geographically uneven ending, and analysis is needed to clarify what these might be and to contribute to the actualization of progressive solutions should such a scenario materialize. As Nafeez Ahmed argues:

> even within such a maladaptive response [i.e. world-system collapse]…there remains a capacity for agents within the global system to generate adaptive responses that, through the power of transnational information flows, hold the potential to enhance collective consciousness. The very breakdown of the prevailing system heralds the potential for long-term post-breakdown systemic transformation (Ahmed, 2017: 88-89).

While we should not underestimate the challenges that progressive movements would face in overcoming the reactionary tide that may tip the early phases of world-assemblage collapse into a violently auto-catalytic spiral – or what Brian Fath and colleagues describe as a "dissolution trap" (Fath et al, 2015)[190] – these possibilities should heighten

[190] As Fath et al explain in their discussion of the adaptive cycle model: "One of the ways that the diversity maintained through small-scale disturbances contributes to the resilience of the system is by cultivating a large stock of resources from which it can pull during a crisis, both in terms of organizations and their relationships…Crisis coordinators that emerge during the [collapse phase] are an example of 'unpredictable combinations of [de novo entities] with existing components that can suddenly establish new domains of influence, opening an entirely new set of adaptive pathways' (Gunderson and Holling 2002: 403). Thus, emergent coordinators set the stage for learning, adaptive capacity, and reorientation of a resilient system successfully navigating through the cycle in the future" (Fath et al, 2015: 3). In contrast, failure to reorient leads to a "dissolution trap" in which the system is unable to regenerate and confronts irreversible breakdown in its structure, functions and feedbacks. They provide four primary means to escape a "dissolution trap" (or irreversible collapse): 1) increasing system modularity to prevent uncontrollable crisis cascades; 2) promote cohesive leadership that can create new forms of order and spread information rapidly; 3) maintain vital functions that are "essential to the continuation of a minimum level of social utility"; and 4) enhance improvisatory capacities, or the ability to suspend prescribed roles in response to immediate needs (ibid: 5). Further, they emphasize the importance of "systemic memory" cultivated in previous phases: "to reorient after crises, a system must reorganize

the urgency that we anticipate how such scenarios may play out and devise collective strategies to counter them.

Overall, as discussed in chapters four and five, the analysis in this dissertation demonstrates the importance of a "navigational" conception of counter-hegemonic agency that is constantly updating itself as local, national, and planetary problematics morph in response to new developments. From this perspective, navigation is both a praxis of understanding and intervening within complex political-economic-ecological-technological systems, as Srnicek and Williams discuss (Srnicek & Williams, 2014), as well as one of modifying and adapting the goals of counter-hegemonic praxis as events in the world unfold and opportunities for transformative agency arise and/or evaporate. In this sense, rather than the "revolution or bust" approach, navigational counter-hegemonic agency requires a rigorous assessment of the most effective ways to enhance our collective power and joyous affects within conditions not of our own choosing. This is a complex and difficult problem – perhaps the most difficult of all problems – that must take place across a geographically and intersectionally uneven global left with variegated vulnerabilities and evaluations of relevance. For example, it can be seen between those who believe a revolution to limit climate change to 1.5°C is still possible, and those who claim that we must prepare for inevitable catastrophic climate change. This problem also inevitably raises the issue of northern privilege relative to front-line communities in the global south, where accepting the impossibility of a 1.5°C limit may be tantamount to a death sentence for many low-lying island communities and others that are already on the

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and access capital, that is, stored emergency capital and pathways for access established prior to crisis…The success of navigating through the fast-moving [collapse phase] is largely a function of system development and decisions made in prior stages" (ibid: 4). While Fath et al come from an apolitical systems modeling tradition and don't reflect on the implications of their insights for preparing for political-economic collapse at national and global scales, the passages cited are richly provocative for those considering how to lay the foundations for progressive regeneration in the wake of collapse.

edge of their resilience threshold (Sealey-Huggins, 2017). It can also be seen between those who believe that we must limit climate change without relying on a massive rollout of carbon capture and sequestration technologies, and those who think we have no chance to prevent runaway climate change without such technologies (Buck & Táíwò, 2019). I don't have all the answers. Yet I believe honestly facing our conditions and constraints, rigorously assessing what is possible and what isn't, is an inescapable necessity, even though it involves irreducible uncertainty. We're living in the era of the least bad option, and trade-offs will be unavoidable, though they must be collectively negotiated across race-class-gender-geographic differences rather than imposed by emergency fiat. Beyond this, grieving our losses and accepting our limitations is sometimes better than defiantly holding out for revolution against all odds. But knowing when the former becomes necessary can never be definitively settled.

The Spatiotemporally Uneven and Combined Planetary Problematic/Solution-Space

This dissertation, following in the traditions of both the Club of Rome's "World Problematique" and (Eco-)Marxist World-Systems analysis, has attempted to investigate the convergence of planetary-scale crises and their implications for the future of the capitalist world-system. As a result, my analysis of both the planetary problematic and its solution-space at present remains abstract, big picture, and global-scale in focus. Indeed, many will notice that my description of possible futures for the world-assemblage leaves out an analysis of how these trajectories will unfold in a spatiotemporally uneven and combined manner, with diverse communities, cities, states, and regions facing their own singular problematics that are nonetheless entangled in an emergent Planetary

Problematic. As a result, like Wallerstein, I may be accused of falling prey to the "fallacy of the domestic analogy", in which "the distinct determinations arising from the coexistence and interaction of a multiplicity of differentiated societies" are subsumed within a "singularly conceived" world-system (or in my case: a singularly conceived Planetary Problematic and solution-space) (Anievas & Nisancioglu, 2015: 16). As Alex Anievas and Kerem Nisancioglu further describe, approaches that fall prey to this fallacy tend to erase "what is arguably unique to any intersocietal system: a super-ordinating 'anarchical' structure irreducible to the historically variegated forms of societies constituting any given system" (ibid: 41).

Indeed, while Planetary Assemblage Theory emphasizes the existence of diverse modes of collective individuation at multiple scales with their distinct problematics and evaluations of relevance, which are integrated and constrained without being *subsumed* by the capitalist world-assemblage, the analysis in chapter six focuses overwhelmingly on the emergent Planetary Problematic and its solution-space. To some extent this is simply the result of my limited cognitive resources; analyzing the planetary crisis convergence and its solution-space is already trying to bite off and chew quite a bit! Supplementing this planetary-scale approach with a deep analysis of its variegated intensities in different states and regions of the world-assemblage and their unique solution-spaces would be an even more daunting challenge.

Nonetheless, following the insights of uneven and combined development theory, such an analysis, even if rudimentary, must be offered in order to adequately theorize the Planetary Problematic. In short, if the Planetary Problematic emerges from relatively autonomous Socioecological, Violence, and Existential Problematics in different states and regions of the world-assemblage, then we must demonstrate *how* both the Planetary Problematic and solution-space emerge from these lower-scale problematics and their unique solution-spaces.

For example, something like a global "Green New Deal" would not of course emerge as a singular legislative package or treaty at the global scale (as if we had a world government), but rather as a cascade of transitions across national, regional, and urban assemblages. More specifically, a GND in the US and/or Europe could have ramifying systemic consequences by changing the selection-pressures that currently constrain national, urban, and local assemblages to follow neoliberal dictates (e.g. austerity and prioritizing the needs of creditors). This would especially be the case if these policies involve a combination of debt cancellation for states in the global south, thereby enabling them to break from extractivist export-led growth; a re-write of multilateral and bilateral trade agreements to prioritize national self-sufficiency in the production of goods; an institutionalization of stringent labor and environmental standards combined with transformation in investor dispute settlement mechanisms to open them up to lawsuits from labor, environmental, and indigenous activists worldwide; the creation of capital controls to enhance national autonomy over economic policy; an overhaul global finance that consigns the powers of credit-creation to democratically accountable public and central banks; and the abolition of intellectual property laws that deprive poorer countries from adopting innovations in green technology (Pettifor, 2019: 74-77, 91; Aranoff et al, 2019). In this way a GND in core countries, combined with multilateral cooperation to transform the structural constraints and selection pressures of the world economy, could facilitate a cascade of transitions at regional, national, and urban scales towards GND principles.

Subsequently, the Planetary Techno-Leviathan that may emerge from the GND would likely not take the form of a “world empire” (at least as traditionally understood) but rather as an unevenly integrated network of national and regional military-security assemblages that remain relatively autonomous (e.g. the “fourteen eyes” of integrated domestic/international intelligence agencies among the US and its NATO allies) (Zappala, 2015). The US and China would likely be the key pioneers in developing and diffusing these apparatuses of surveillance and force mobilization, thereby changing the selection-pressures of the world-assemblage to favor regimes that import their technologies and follow similar norms of draconian securitization. It is possible that a PTL would involve the imposition of something like a “world empire” by a single hegemonic power (Arrighi, 2010), perhaps if the US develops conjoined preponderance in AI and outer space weaponization, thereby giving it control of the “ultimate high ground” (Deudney, 2020). But given China’s rapid advances in AI and capacities to challenge US spacepower (at least asymmetrically, e.g. through anti-satellite weapons) (Lee, 2018), it appears more likely that a PTL would take the form of a bipolar or multipolar world order characterized by partially integrated yet relatively autonomous national and regional security assemblages.

Alternatively, crisis and stagnation in the GND could lead to an uneven and combined transition towards democratic ecosocialism. While the GND would begin the process of reshaping the rules and selection-pressures of the world-assemblage to prioritize social welfare and sustainability over economic growth, its subsequent crisis *could* push core countries to cooperatively construct a more egalitarian post-growth world order (that is, if transnational labor and environmental justice movements are strong enough, and if cognitive-affective assemblages in core countries are sufficiently primed for an irreversible shift beyond individualist consumerism). Transitions toward ecosocialist principles in Europe and the US may foster strengthened commitment from key emitters like China and India to accelerate emissions reductions, both due to changing norms and the erosion of global competitive pressures to prioritize GDP growth and military build-up. These shifts among key emitters would then facilitate the creation of binding international treaties to equitably share the world's remaining carbon, land, nitrogen, phosphorous, and freshwater budgets (Rockström & Klum, 2015: 152), with rich countries reducing their emissions more rapidly and agreeing to reduce their overall material-energy-throughputs. States that resist compliance with global plans and/or fail to ensure a just transition for workers could be penalized through tariffs on exports and/or restrictions on technology and knowledge transfers, in this way forming a set of negative feedbacks that operate similarly to contemporary global economic governance (while promoting diametrically opposed ends). The result would be an ecosocialist world order that is less than world government but more than an aggregate of sovereign ecosocialist states, which would be integrated by a reformed and empowered UN general assembly, democratically shaped global plans for transforming industrial metabolisms and sharing resources, and carrot and stick mechanisms to limit the capacities of "rogue fossil states" (Russia comes to mind) to continue their polluting ways.

Overall, the future of the world-assemblage will predominantly be shaped by the solutions adopted in the US, Europe, China, and India, which collectively account for over 50% of global emissions and GDP. However, this is not to say that trajectories of the planetary crisis convergence in other states and regions will be insignificant in shaping the overall emergent trajectory of the world-assemblage. For one, struggles over the SEP solution-space in OPEC and other key oil-producing countries will be critical in determining whether we limit climate change to 2°C, though this will also require rich importing countries to provide compensation mechanisms for their stranded assets (Bolton et al, 2020: 32). Furthermore, transitions toward a GND or ecosocialist principles in middle powers (e.g. countries like New Zealand, Iceland, and Scotland, which have been at the forefront of post-GDP "Wellbeing Economy" initiatives) would provide models that could diffuse and inspire other states (WEAll, 2020). Revolutions in states from the global south towards democratic ecosocialist principles, which should not be discounted in the upheavals to come, would also inspire and embolden similar movements in the global north, and their systemic consequences would be greater if occurring in key oil producing and other extractivist states. On the other hand, rightwing and/or quasi-fascist takeovers in key states in the global south can embolden reactionaries around the world and potentially lay waste to crucial ecosystems with critical implications for earth system thresholds (e.g. Bolsonaro's takeover in Brazil, which has accelerated deforestation in the Amazon and pushed it closer to a tipping point, which may then further push the 1.5-2 degree target out of reach and trigger a hothouse earth pathway) (Lovejoy & Nobre, 2018).

Looking beyond states, movements for indigenous sovereignty and peasant-based agroecology in the global south (e.g. La Via Campesina) can have global systemic consequences by creating new human rights norms (e.g. the 2007 Declaration of

Indigenous Rights) and influencing the UNFCCC negotiations to integrate indigenous forms of knowledge and agroecological solutions to climate change and food insecurity (Claeys & Delgado, 2015). These movements have also inspired counter-hegemonic modes of collective individuation in the US and Europe – seen in the growth of Transition Towns, Ecovillages, Solidarity Economies, and other grassroots sustainability initiatives inspired by "permaculture" principles – thereby influencing transformations in cognitive-affective and political-economic assemblages in key nodes of the world-assemblage (Holmgren, 2002; Penha-Lopes et al, 2019). Furthermore, anti-extractivist struggles across the global south can have critical implications for the global energy transition. Not only will struggles against fossil fuel extraction play a crucial role: for example, if struggles against lithium extraction throughout the Andean salt flats of Argentina, Bolivia, and Chile succeed, then this could bolster progressive GND advocates in the global north aiming for energy demand reductions and a public transport rather than private car based electrified transportation system (which would require far less lithium extraction) (Aronoff et al, 2019: 142-153). In turn, struggles in the US to reduce energy demand and create a more just US trade policy that prioritizes labor and environmental protections would go a long way towards strengthening anti-extractivist movements across the global south, showing how "nodes of the vast supply chains of the renewable transition are potential sites of solidarity across borders" (ibid: 159).

Overall, the analysis in chapter six is not only weak on the geographically uneven and combined nature of the planetary problematic, but also on the question of agency in pushing the world-assemblage towards alternative trajectories. Can we identify competing "hegemonic blocs" each with different articulations of the Planetary

Problematic and its possible solutions (e.g. business-as-usual advocates, green capitalists, ecosocialists, and (eco)-fascists)?[191] How might these blocs materialize through diverse coalitions across states, regional trading blocs, security alliances, national and transnational capitalist fractions, think tanks, scientists, media networks, and transnational social movements? What is the respective role of norms, ideas, international institutions, transnational advocacy networks, and the military and economic power of leading states in sustaining or altering the selection-pressures of the world-system as a whole, thereby keeping it trapped within its current collapse trajectory or pushing it towards alternative attractors? Such questions bring us more squarely within the terrain of IR (broadly understood) and demonstrate how the discipline can make valuable contributions to the broader transdisciplinary effort of anticipating the possible trajectories of the planetary crisis convergence and contributing towards counter-hegemonic responses.

Between Hope and Pessimism

As we near the end of our abstract journey through the planetary crisis convergence, it is worth recalling that we are embodied beings with deep longings and fears (often suppressed or simply dormant beneath the surface of consciousness). It is difficult if not impossible to honestly confront our predicament without feeling

[191] See the work of Mario Candeis, which maps four primary competing hegemonic projects: authoritarian neoliberalism, which attempts to contain contemporary crises through the same mechanisms of financialization, austerity, privatization, and de-democratization; green capitalists, who aim to maintain capitalist class power by "greening" growth and shifting towards Neo-Keynesian regulatory principles; the Green New Dealers, who seek an alliance between working classes and the progressive fractions of global capital; and ecosocialists, who aim to relocalize and democratize economic decision making while promoting collective forms of consumption rooted in universal forms of social security (Candeis, 2012). This work is a good start, though we need to go further by mapping how these competing projects manifest in different states, international organizations, and through competing transnational advocacy networks and social movements across the domains of energy, food, finance, information technology, urban planning, and other areas.

overwhelmed or going numb. Even as I write I only barely feel the weight and tension of this event horizon in which we're swirling and from which we'll be spat out from the other side into who knows where (extinction? collapse? a techno-authoritarian nightmare? a better world?). I shift between intellectual fascination (undoubtedly a coping mechanism to deal with the underlying fear), gnawing anxiety, numbness, and the sensation of dipping my proverbial toes into a boundless ocean of grief.

Gramsci once remarked that we should maintain an optimism of the will alongside the pessimism of the intellect. Indeed this stance is as relevant as ever, though we should reflect on what an "optimism of the will" can and arguably should mean in the context of our 21st century planetary predicament. For the ecomodernists and new optimists this takes the form of a "can do" spirit of apolitical innovation that reminds us of the technological wonders of the modern world and the promise of breakthroughs yet to come (Lynas, 2011; Brand, 2012; Asafu-Adaye et al, 2015; Pinker, 2018). Green New Dealers, ecosocialists, and degrowth advocates rightly critique the faith-more-than-reason based arguments of these optimists while countering with a faith of their own: that mass social movements can save us, that there *is* still time for eco-social transformation to prevent climate chaos and create a more beautiful world (Klein, 2019; Magdoff & Williams, 2017; Foster et al, 2011; Aronoff et al, 2019). In short, whether the hope is placed in technological innovation to enable continuation of the progress-understood-as-economic-growth trajectory, or social movements to enable eco-social transformation towards a more egalitarian and sustainable post-capitalist world (or both technological innovation *and* eco-social transformation, as the ecomodernist left hopes for), a leap of faith is required. Giorgos Kallis may best capture the predicament we all confront when he writes: “whether we are for or against degrowth, we are all engaging in wishful thinking” (Kallis, 2018: 188).

Increasing numbers across the worlds of academia, activism, and beyond are rejecting these faiths and forging new intellectual, practical, emotional, and (sometimes) spiritual responses to the planetary predicament. These thinkers aim to go beyond these “green positivity” narratives and their diverse brands of “hopium”, which they critique for clinging to impossible (or at best highly unlikely) dreams that constrict our capacities to grieve for the inevitable and irreparable losses we confront, to squarely face our fears of death and human extinction, and to find new meaning and purpose in life beyond the frantic search for “solutions” (Bendell, 2018, 2019; Baker & Harvey, 2017; Scranton, 2018; Grove, 2019; Dark Mountain Project, 2017). For example, Roy Scranton skewers what he calls the “fictions” of eco-social transformation and/or technological miracles as “farcical daydreams against the coming chaos, popsicle-stick castles in a hurricane wind”, instead counseling us to confront our fears of death and cultivate a more humble understanding of our cosmic insignificance (Scranton, 2020). In the context of IR, Jairus Grove comments on the remarkable absence of pessimistic catastrophism throughout the discipline (at least “on paper”): “the seething doom of our current predicament thrives at the conference bar and in hushed office conversations but not in our research” (Grove, 2019: 21). Breaking from both the continuationist consensus and the hopeful search for solutions, Grove calls for a form of “negative thinking as an alternative to the endless rehearsing of moralizing insights and strategic foresight”, which “celebrates useless thinking, useless scholarship, and useless forms of life at the very moment we are told to throw them all under the bus in the name of survival at all costs” (ibid: 25). Coming from a more literary angle, the Dark Mountain Project summons forth a new practice of "uncivilized" literature that breaks from the stories of endless progress that our civilization has spoon-fed us from childhood, instead beckoning us to reckon head on with the "inevitable" collapse of civilization. They ask, "what would happen if we looked down? Would it be as bad as we imagine? What might we see? Could it even be good for us? We believe it is time to look down" (Dark Mountain Project, 2017).

It is both easy and challenging to go the route of the "new pessimists" (as we might call them). In short, as this dissertation can attest to, the argument that "we're fucked" is compelling, even if what that means must be nuanced by appreciating the geographically and intersectionally uneven vulnerabilities that constitute the "we". At the same time, any proclamation that "we're fucked" must bear the weight of the incalculable losses in lives, ways of life, species, and ecosystems along with the unfathomable suffering that new pessimists accept as given. I am thus uncomfortable with at least certain forms of this perspective, which can become a kind of escapism that doesn't reckon on a deeply embodied level with the grief, pain, terror, and rage that our predicament must provoke. Perhaps more importantly, as Scranton himself recognizes, it can take the form of an attempt to remain "above the fray", thereby "never risking the embarrassment of a 'naïve reaction,' never risking being taken in by an erroneous fiction because never making the commitment to any specific future" (Scranton, 2020). In other words, rather than risking the fight for a better future, risking the pain and disappointment of failure (and perhaps, for an academic, the intellectual embarrassment of putting one's weight behind utopian aspirations), new pessimists may lapse into an apolitical quietism that brings one the comfort of likely being proven right in the end. “An enviable position, so high above the fray!” (ibid).

In contrast, I believe it is possible (if challenging and somewhat contradictory) to navigate a path between the more hopeful and pessimistic positions. On one hand, as noted earlier, we should avoid the “revolution or bust” approach, which is not just liable to end in disappointment but more importantly risks constraining the goals of praxis within narrowly conceived limits. By setting our sights on the tunnel vision of eco-social revolution, we may disable the flexibility needed for climate justice and allied movements to morph and adapt in ways that enable us to maximize our collective power to act and flourish within the constraints that limit us. On the other hand, I believe we should (at least for now) resist the temptation of the “collapse is inevitable” thesis, which again limits our praxis and ignores the potentials for transformative agency that may emerge in the coming upheavals. Nonetheless, as Joanna Macy advises, while we remain open to the uncertainty of the future we should also avoid attaching to the hoped for (i.e. revolutionary and progressive) results of our actions. “Active hope”, in this sense, means we do our best within our circumstances, not because we believe that we might succeed but because service in the interest of supporting life and reducing suffering is an end in itself (Macy & Johnstone, 2012). At the same time, as Carolyn Baker, Jem Bendell, and practitioners of “deep adaptation” counsel, active hope for a better future should not constrict and distort our ability to honestly confront and emotionally process our planetary predicament. The question here, always difficult to determine in practice, is whether our hope is grounded in current realities (as best as we are able to determine them) or a distraction from our pain and thus a distorted expression of our desire to serve life in the best way we can during these times. In this sense, as Jem Bendell writes, "hope" is not necessarily "a good thing to maintain, as it depends on what one is hoping for" (Bendell, 2018: 13). In contrast, by abandoning certain hopes, as Tommy Lynch says, we may "open up a space for alternative hopes" (quoted in Bendell, 2018: 13).

I believe an "optimism of the will" understood in this sense can provide a compass to help us navigate through the planetary crisis convergence. On one hand, democratic ecosocialist transformation during this century of upheaval is not impossible, and this is a goal worth believing in and fighting for. The future is open, and "we do not yet know what a [planetary crisis convergence] can do" (Deleuze and Guattari, 2004). On the other hand, our optimism should not reside in the belief that we can and will successfully transform the capitalist world-assemblage, but that we can collectively discover new ways of life and new sources of meaning, purpose, joy, and community whatever the future brings.

Conclusion

"The world is an egg" (Deleuze, 2004a: 268-269). "The old is dying and the new cannot be born" (Gramsci, 1971: 276). Planet earth has thrust the imperative of individuation upon us. The current crisis is simultaneously unprecedented and a repetition of ancient dynamics in the evolution of humanity and life on earth (and perhaps the cosmos at large). This dissertation has been a personal exercise in intellectual clarification of the planetary predicament we face and its possible futures, one that I hope will be useful to others. May we be worthy of the times in which we live and the events that will befall us.

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